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SCIENCE

31 October 1958

Volume 128, Number 333

6 NOV 3 - 1958
Cont. Copy

526349

Editorial Imaginary Tour 1057

Articles Modifying Weather on a Large Scale: *H. Wexler* 1059

Current proposals are either impractical or likely to produce cures that are worse than the ailment.

The Test of Simplicity: *N. Goodman* 1064

Simplicity is a test of the effectiveness of scientific theories; but what is the test of simplicity?

Richard Goldschmidt, Biologist: *C. Stern* 1069

News of Science War Prevention and International Cooperation: Statement of Third Pugwash Conference; other events 1071

Book Reviews H. R. Hays' *From Ape to Angel,* reviewed by *W. L. Warner*; other reviews 1077

Reports Cultures of Gonads of Mammalian Embryos: *E. A. Holyoke* and *B. A. Beber* 1082

Ultraviolet Mitigation of X-ray Lethality in Dividing Yeast Cells: *M. M. Elkind* and *H. Sutton* 1082

Quantitative Relations between Stages of Leaf Development and Differentiation of Sieve Tubes: *W. P. Jacobs* and *I. B. Morrow* 1084

Changes in Tryptophan Peroxidase Activity in Developing Liver: *A. M. Nemeth* and *V. T. Nachmias* 1085

Psychological Brightness Reduction of Simulated Flashes from a Polyhedral Satellite: *R. H. Wilson, Jr.* 1086

Physicochemical Study in Water of a Mucoprotein with Virus-Inhibiting Activity: *M. Maxfield* 1087

Artificially Induced Circulation of Lakes by means of Compressed Air: *W. R. Schmitz* and *A. D. Hasler* 1088

Thermocouple for Vapor Pressure Measurement in Biological and Soil Systems at High Humidity: *L. A. Richards* and *G. Ogata* 1089

Effects of Selenium and Vitamin E on White Muscle Disease: *O. H. Muth* et al. ... 1090

Anaphylaxis in Passively Sensitized Guinea Pigs after Subcutaneous Eliciting Injection: *S. H. Stone* 1090

Departments Fifteenth International Congress of Zoology; Forthcoming Events; Equipment 1092

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Imaginary Tour

The clang of power shovels and the chuff of bulldozers at a building site on the Mall in Washington serve to remind us that things are looking up for the Smithsonian Institution. For it is on this site, opposite the Department of Labor and within view of both the Capitol and the Washington Monument, that excavation has begun for the first of several building projects for the U.S. National Museum, which has been operated by the Smithsonian Institution since its inception one hundred years ago and which has never been adequately housed or financed. The new building, a $36 million, five-story structure of modern design (an architectural rendering is reproduced on page 1074), will house the Museum of History and Technology.

It was only after World War II that Congress began to step up appropriations for the museum and to plan for a substantial expansion of its facilities. At present only a small fraction of the vast collection of 44 million objects is on public display in the several buildings that make up the museum: the National Air Museum, the Natural History Building, the Arts and Industries Building, and the Smithsonian itself. With a few laudable exceptions, the exhibits are all-too-reminiscent of the worst taste of the Victorian Age; this is understandable, for it was during that Age that they were planned and, until recently, little money has been available to change them. The exhibits crowd old-fashioned glass-walled cabinets, cluster along the walls, hang from the ceilings. The visitor may sometimes feel that he himself is merely an animated specimen encased in a gigantic what-not.

But this is changing. The Natural History Building, erected in 1911, is being renovated, and its exhibits are being transformed into the eye-catching and instructive displays that characterize the best of the modern museums; when two new wings, already authorized, are completed, the building will be adequate for both display and research functions.

The Air Museum has an outstanding collection, but much of it is in warehouses. The objects that are on display are housed in a sheet-iron shed and are so crowded together that the visitor must thread his way among them with distracting caution. A new building to house this collection and give it the space it needs will be put up on the Mall opposite the National Gallery of Art.

Of all of these projects, the new Museum of History and Technology will be the first to be completed. The collections that will form the nucleus for its displays are now housed in the Arts and Industries Building, which was put up as a "temporary" structure in 1881. With the aid of the director, Frank Taylor, and the blueprints for the building, we were recently able to take an imaginary tour through it. We were much impressed by plans for the fine auditorium completely equipped for scientific demonstrations and wired for television production; by the classrooms for school children; by the carefully planned halls equipped with working models of apparatus so arranged as to let the visitor follow the historical development of the subject and understand the principles involved. There is much here for children, for nonspecialist adults, and even for the specialist whose background in his subject may be incomplete. Nothing has been neglected to make this one of the world's finest museums.

At the beginning of the museum's second century, the outlook is bright. We may confidently expect the Smithsonian Institution to remain outstanding in research and to become one of the world's greatest public museums. This development will permit the institution to carry out, more effectively than ever, the wishes of its founder—that it have as its aims "the increase and diffusion of knowledge among men."—G.DuS.

New amplifier battles "noise"

Four-stage junction diode amplifier was developed at Bell Telephone Laboratories by Rudolf Engelbrecht for military applications. Operates on the "varactor" principle, utilizing the variable capacitance of diodes. With 400-mc. signal, the gain is 10 db. over the 100-mc. band.

The tremendous possibilities of semiconductor science are again illustrated by a recent development from Bell Telephone Laboratories. The development began with research which Bell Laboratories scientists were conducting for the U. S. Army Signal Corps. The objective was to reduce the "noise" in UHF and microwave receivers and thus increase their ability to pick up weak signals.

The scientists attacked the problem by conducting a thorough study of the capabilities of semiconductor junction diodes. These studies led to the conclusion that junction diodes could be made to amplify efficiently at UHF and microwave frequencies. This was something that had never been done before. The theory indicated that such an amplifier would be exceptionally free of noise.

At Bell Laboratories, development engineers proved the point by developing a new kind of amplifier in which the active elements are junction diodes. As predicted, it is extremely low in noise and efficiently amplifies over a wide band of frequencies.

The new amplifier is now being developed for U. S. Army Ordnance radar equipment. But it has numerous other possibilities. In radio astronomy, for example, it could be used to detect weaker signals from outer space. In telephony, it offers a way to increase the distance between relay stations in line-of-sight or over-the-horizon communications.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

31 October 1958, Volume 128, Number 3331 SCIENCE

Modifying Weather on a Large Scale

Current proposals are either impractical or likely to produce cures that are worse than the ailment.

H. Wexler

Two streams of radiant energy, one directed downward and the other upward, dominate the climate and weather of the planet Earth. The downward stream of energy consists of the residual solar radiation absorbed by the earth's surface and atmosphere after about one-third is lost by reflection from aerosols, clouds, and earth. The upward stream is infrared radiation emitted to space by the earth and atmosphere, mostly from atmospheric water vapor, clouds, carbon dioxide, and ozone.

The latitudinal distribution of both radiative streams, averaged for the Northern Hemisphere winter third of the year (November, December, January, and February), is shown in Fig. 1, plotted from unpublished data computed by Gabites (*1*).

The climatic zones of decreasing temperature poleward are a direct result of the imbalance of heat received and lost. But this same temperature gradient creates a meridional circulation which transports poleward the excess energy received at tropical latitudes to make up the deficiency in polar regions. In the process, the winds and their burden of energy in the form of real and latent heat create weather.

In seeking to modify climate and weather on a grand scale it is tempting to speculate about ways to change the shape of these basic radiation curves by artificial means. Various proposals have been made for changing the albedo or reflectivity of large portions of the earth's surface in order to influence the percentage of solar radiation absorbed. Since the albedo of most of the earth's natural surfaces, such as ocean, forest, and ordinary bare ground, is quite small to begin with [3 to 14 percent (*2*)], and since it would be unwise to blacken grassland, which has an albedo as high as 30 to 35 percent and which is used for fodder, there remain only the deserts and snow fields to be considered as candidates for substantial albedo changes of the earth's surface.

Blackening Deserts

Light-colored deserts such as the Mojave and Death Valley have albedos of between 25 and 30 percent, and this is presumed to be the case also for the Sahara and other tropical deserts. We select deserts in the tropics because this is the zone of average net excess of solar radiation.

From 40° north latitude to 40° south latitude the ratio of land to water is about 1:3. About one-tenth of the land surface in this belt is desert, or one-thirtieth of the total area.

Suppose by laying down a layer of carbon dust over the deserts the albedo is reduced by one-half (we neglect for the time being the practical problems of logistics and maintenance of the black surface against wind erosion and washout). The average albedo of the 40°N–40°S zone is 30 percent (*3*). If one-thirtieth of this area has its albedo reduced by one-half, then the average albedo of the total zone is reduced by about ½ percent. This will increase the average energy absorbed by the earth's surface in that zonal strip by 3.6 langleys (ly) (*4*) per day and the average temperature by 0.4°C.

Blackening the Polar Icecaps

The other principal areas of light-colored natural earth's surface are the polar icecaps. Icecaps one to two miles thick, such as those in Greenland and Antarctica, are not considered to be worth blackening, since some of the extra absorbed energy will merely be utilized in melting the surface layer, from which water will percolate down into the snow and freeze again without runoff. There might be a slight increase in evaporation, but the process would be slow and perhaps self-defeating (*5*).

The thinner ice of the Arctic ice pack, of the order of 10 feet thick, is more susceptible to modification by blackening. The average albedo of the Arctic ice during the summer, when open pools of water are found, is probably close to 50 percent. It has been estimated that about 1 meter of the surface ice is melted in the course of the Arctic summer (*6*). What would be the increase in melt if the surface could be so blackened as to reduce the average albedo from 50 to 10 percent?

In 1953, when Fletcher's Ice Island (T-3) was near latitude 86°N, longitude 96° to 82°W (*7*), the monthly average insolation values shown in Table 1 were observed. The average value is nearly identical with the May–October 1950 average of 405 langleys per day observed by Yakovlev (*8*) on the Soviet Ice Floe Station North Pole–2 while it was in the

The author is director of meteorological research of the U.S. Weather Bureau, Washington, D.C.

Table 1. Average daily insolation, Fletcher's Ice Island, 1953.

Month	Av. daily insolation (ly)
May	534
June	650
July	445
August	309
September	78
Average	403

vicinity of latitude 76°N, longitude 166°W.

If the ice is assumed to be fresh-water ice, then the melting of 1 meter would require 7200 langleys. Since the natural ice pack albedo is assumed to be 50 percent, this means that 25 percent of the 59,000 langleys of the insolation received during the melt period of May, June, July, and August is utilized in melting the ice. The remainder of the absorbed solar radiation is used in heating the ice to the melting point, and is absorbed by the sea water, fresh-water pools, and the air.

Suppose, now, that the pack-ice albedo is reduced by blackening from 50 to 10 percent. This will have two effects: first, 90 percent of the insolation will be absorbed instead of 50 percent; second, if the summer sky over the Arctic pack is overcast, as it generally is, then as Fritz (*9*) showed, the insolation itself will be reduced because of a decrease of secondary reflection from the cloud base. As an illustration of the latter point, if the solar zenith distance is 60° and the ratio of the cloud thickness to the mean free path of the radiation in the cloud is 3, then a decrease in albedo from 50 to 10 percent will decrease the insolation by one-sixth. If the same fraction, ¼, of the insolation (I) is utilized in melting the ice, then the energy so used for the 50-percent albedo is $I/2 \cdot 4$, while for the 10-percent albedo it is $I(9 \cdot 5 \cdot 1)/(10 \cdot 6 \cdot 4)$. The ratio of the latter to the former is 3:2, showing that 50 percent more ice, salt or fresh, is melted when the albedo is decreased from 50 to 10 percent.

Logistic Requirements

To lay down a black layer 0.1 millimeter thick (*10*) over the Arctic ice pack and adjacent snow fields (from latitude 65°N to the North Pole), an area equal to $24 \cdot 10^6$ square kilometers, would take 1.5 billion tons of carbon. Similarly, to blacken the tropical deserts, an area equal to $8.5 \cdot 10^6$ square kilometers, would take 0.5 billion tons of carbon. The deposit of an even, uniform layer could best be accomplished by low-flying airplanes. If the Globemaster (C-124) type of cargo plane, capable of carrying 10 tons of carbon, were used, it would take 100 million sorties to lay down 1 billion tons of carbon black. This would take considerable time, and meanwhile wind erosion, melting, frost, and snow deposits would tend to dissipate or whiten the blackened snow cover, while drifting sand would tend to cover the blackened cover in the deserts.

Ice Clouds and Outgoing Radiation

As an alternative to blackening large areas of the earth's surface to convert a greater percentage of the incoming solar radiation to useful energy, let us examine the possibility of reducing the return of infrared radiation to space. The formation of a sufficiently thick cloud having particles of diameters of about 10 microns—comparable to the wavelength of the strongest outgoing infrared radiation—can reduce the outgoing radiation and so decrease surface cooling. This has been demonstrated in a striking fashion in the ice fogs which generally form at temperatures of −30°C or below when moisture sources are available. In inhabited areas, such sources are chimney and steam vents; in uninhabited areas, these fogs result from openings in the ice cover of bodies of water or even from caribou herds and the like.

An example of the effect of an ice fog on the net outgoing radiation is shown in Table 2 by data collected at Ladd Air Force Base by Robinson and MacLeod (*11*).

The appearance of an ice fog caused the net loss of radiation to decrease to one-eighth of the initial value, and this decrease occurred in spite of the decreasing solar radiation received from the setting sun.

The ice crystals comprising the ice fog are equant solid ice particles with rudimentary crystal faces, of diameter between 10 and 20 microns; they have been given the name "droxtals" by Thuman and Robinson (*12*). They are formed by the freezing of supercooled water drops condensed from water vapor discharged into the atmosphere from chimneys and steam vents. The fog thus formed is confined vertically by the strong temperature inversion and extends upward about 100 feet. If the whole layer between the ground and the inversion top could be filled by an ice fog, the outgoing radiation from the surface would approach zero and the top of the ice fog would serve as the "black-body radiator," in place of the ground. Since the top of the ice fog would be at a higher temperature than the ground, the radiation loss to space would thus increase. This would be a short-lived process, however, since the top of the ice fog would cool rapidly, creating a sharp inversion just above, and diminishing the outgoing radiation, as is illustrated in Fig. 2.

The only way in which the *total* radi-

Table 2. Effect of ice fog on net outgoing radiation, Fairbanks, Alaska, 4 Feb. 1953.

Time of day	Temperature	Net outgoing radiation (ly/min)	Visibility (mi)	Ice fog
1415	−31°C	0.076	10.0	None
1425	−29°C	—	—	None
1500	—	0.041	—	Ice fog
1540	—	—	0.50	Ice fog
2155	−41°C	—	0.25	Ice fog
2215	—	0.009	—	Ice fog

Table 3. Radiation losses to space in Fairbanks, Alaska, in January, when black-body (B-B) radiating surface is at various levels.

Temp. of B-B radiating surface	Atmospheric pressure (mb)	Loss (ly/min) from			Total loss
		Radiating surface	Water vapor	CO_2	
−19.4°C at earth's surface	1000	0.096	0.142	0.041	0.279
−10.5°C at top of inversion	832	0.123	0.126	0.041	0.290
−55.9°C at tropopause	209	0.134	0.009	0.041	0.184

ation loss to space from the ground and the atmosphere could be reduced would be to have the ice fog extend high enough so that the temperature of its top would always remain lower than that of the ground. This, in most cases, means extending the ice fog to the tropopause. Table 3, computed with the aid of Elsasser's diagram (*13*), illustrates what could be accomplished in reducing the total outgoing radiation under average January conditions at Fairbanks, Alaska. Thus, if the effective black-body radiating surface is transferred from the true ground to an artificial one at the tropopause, there is a 34-percent decrease in the total outgoing radiation to space from the vertical air column and underlying ground.

Manufacture of the Ice Cloud

The cheapest and most effective way of producing an ice cloud would be by application of nuclear energy. Let us imagine the explosion of ten really "clean" hydrogen bombs, of 10 megatons each, at optimum depth in the Arctic Ocean to produce steam, which would then gush into the atmosphere, condense into water droplets, and freeze. If the entire 100 megatons of energy were used in this way to convert sea water into droxtals of 14-micron median diameter, and if these particles were spread uniformly over the area from latitude 65°N to the Pole, from the surface to the tropopause at 8 kilometers, there would then be approximately 1 droxtal per cubic centimeter and therefore 1 square centimeter of obstruction per square centimeter of area—in other words, the obscuration of the surface by the ice cloud would be complete. Diffuse infrared radiation loss from the surface would then be diminished to at least $e^{-2} = 0.14$ of the original value, in agreement with Table 2. The explosions would have to be well distributed throughout the Arctic basin to take advantage of the existing winds to spread the floating droxtals over the entire basin but prevent transport of large quantities outside. A winter high-index situation, characterized by strong westerly winds throughout most of the troposphere at middle latitudes, rotating about a polar vortex, would "contain" the polar atmosphere and thus represent the optimum circulation pattern for establishment of a widespread, quasipersistent ice cloud over the Arctic basin.

A difficult requirement of the experiment would be to insure the conversion of a major portion of the vaporized sea water into droxtals of the median diameter best calculated to block off infrared radiation from the ground and to remain in the atmosphere for the longest time.

If the experiment were performed in winter, there would be no appreciable solar radiation to encourage the evaporation of the ice particles. After a while, of course, some particles would tend to be carried southward into sunlit areas. Because of heating of these particles by solar radiation and the warming of the carrier air currents by the usual subsidence accompanying southward-moving polar air masses, the droxtals would evaporate and thus not interfere with incoming solar radiation at middle and lower latitudes.

Effects of Ice Cloud on Radiation Balance and Temperature

With reference to Fig. 1, suppose that the return radiation to space from latitude 65°N to the Pole is reduced by 50 percent by the presence of the 8-kilometer-deep ice cloud. This decrease, which is represented by the shaded area under the curve marked OR, amounts to an average of 150 langleys per day for each square centimeter of the $24 \cdot 10^6$ square kilometers comprising the north polar area. This area is about 5 percent of the total area of the earth. If the in-

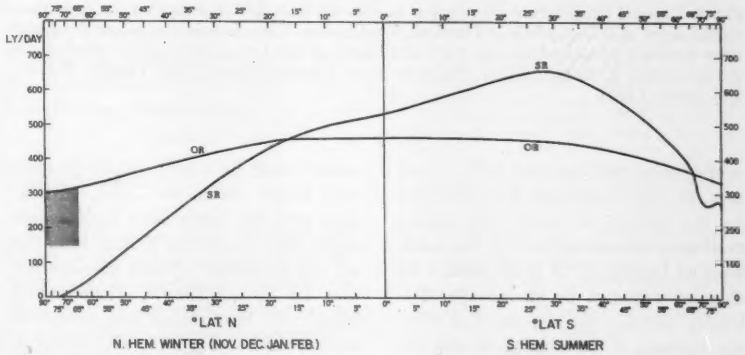

Fig. 1. Latitudinal distribution of unreflected solar radiation (SR) and outgoing radiation (OR) for the Northern Hemisphere winter third of year (November, December, January, and February).

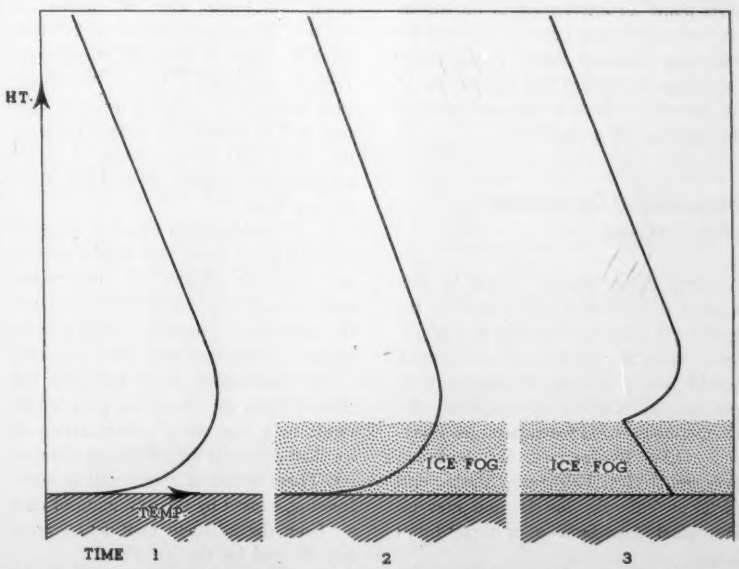

Fig. 2. Effect of shallow (a few hundred feet thick) ice fog on surface temperature inversion.

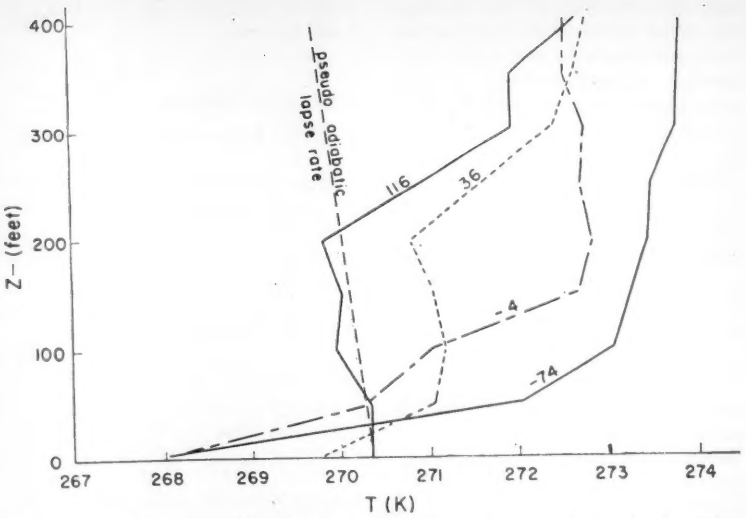

Fig. 3. Vertical temperature distribution at selected times before and after fog formation on the night of 9 Dec. 1947, in Hanford, Washington. Time in minutes before (—) and after the fog is presumed to have reached a height of 200 feet is indicated by numbers on the soundings. Z, height; T(K), temperature in degrees Kelvin. [After Fleagle, Parrott, and Barad (*14*)].

coming solar radiation remains the same, then, in order to maintain a heat balance for the earth as a whole, each square centimeter of that portion of the earth south of latitude 65°N must increase its outgoing radiation by an average of 8 langleys per day; this represents an average warming of the atmosphere and underlying surface of 1.3°C. If the compensating heating were confined only to the region from latitude 0° to 65°N, the warming would be 2.8°C. The "cross-over point" or intersection of the incoming solar radiation curve (SR) and the outgoing radiation curve (OR) would be displaced toward the equator by 1° of latitude in the first case and by 2° of latitude in the second case.

Meteorological Consequences of the Ice Cloud

Arctic basin. The ice cloud, by preventing direct loss of radiation from the surface to space and serving as a blackbody radiator upward and downward, would greatly increase the surface temperature by eliminating completely the characteristic surface-temperature inversion (*12*). In January, the inversion averages 9°C at Fairbanks, Alaska, and 17°C at Yakutsk, Siberia, and may on individual days be two or three times larger.

The loss of radiation at the top of the ice cloud but not at the bottom would result in a temperature decrease with height within the cloud, particularly over the Arctic basin itself, where appreciable quantities of heat from the sea are conducted upward through the thin ice cover. Fleagle, Parrott, and Barad (*14*) have shown that, even over land, a shallow fog layer will change a stable lapse rate to a steep one, and that, if certain critical conditions of absorption coefficient and coefficient of eddy conductivity above the fog layer are fulfilled, the lapse rate will beome unstable. The appearance of a 200-foot-thick fog layer at Hanford, Washington, (Fig. 3) changed a 5°C-per-100-foot surface inversion to a slightly unstable lapse rate and increased the surface temperature by 2.3°C in two hours. A strong temperature inversion formed just above the fog layer.

In the artificial ice cloud, a similarly induced steep lapse rate would encourage convective currents and condensation which would help renew the cloud, while the tropopause inversion would prevent upward diffusion of the cloud particles.

The elimination of the radiation loss directly from the Arctic ice pack would result in a less heavy accumulation of ice than normally occurs during the winter. There would of course still be some freezing, caused by the advection of cold air from the adjacent continental areas not affected by the ice cloud.

The area of the present Arctic ice pack is roughly $8 \cdot 10^6$ square kilometers. If the ice cloud persists for the four winter months and eliminates 80 percent of the average radiation loss of 0.06 langleys per minute (*15*) from the ice surface, this would amount to a total of $5.5 \cdot 10^{18}$ calories saved each day of the 4-month winter period, or $1.8 \cdot 10^{18}$ calories per day averaged for the year. Now the annual heat transport poleward across latitude 63°N in the North Atlantic Ocean, according to Jung (*16*) is $0.7 \cdot 10^{18}$ calories per day. Presumably, a large fraction of this energy flows into the Arctic basin and very little energy enters through the Bering Straits from the Pacific Ocean. Thus, the ice cloud would prevent direct radiative loss of energy to space at a rate at least twice that at which energy is brought in by ocean currents to the Arctic basin. However, as is indicated in Table 2, there would still be a leakage of energy to space by radiation from the top of the ice cloud, which would be supplied both by conduction of heat through the ice and by advective transfer of energy from the south. Since there would be no ice cloud in summer, the normal insolation would induce normal summer melting of the ice. Thus, it appears that one of the principal effects of the ice cloud would be to accelerate greatly the disappearance of the Arctic ice pack which is now believed to be under way (*17*).

It is reported by Ahlmann that in the 20-year interval from 1924 to 1944, the Arctic ice pack decreased in area from $9 \cdot 10^6$ to $8 \cdot 10^6$ square kilometers. Also, the average thickness decreased from 365 centimeters in 1893–96 to 218 centimeters in 1937–40, or by an extrapolated value of 65 centimeters from 1924 to 1944. If the ice has 15-per-mill salinity, its heat of fusion is 50 calories per gram. The melting of $8 \cdot 10^{18}$ grams of ice is equivalent to $4 \cdot 10^{20}$ calories in excess energy received in the 20-year period, or $0.055 \cdot 10^{18}$ calories per day. This represents about 8 percent of the net heat transport poleward by Atlantic Ocean currents across latitude 63°N, as computed by Jung (*16*), or 0.15 percent of the net energy transport (both real and latent) by winds across latitude 70°N, as computed by Starr and White (*18*). In other words, an increase of 8 percent in oceanic transport of energy northward into the Arctic basin, or of 0.15 percent in air transport of energy, could account for the observed melting of the Arctic ice pack in the period from 1924 to 1944.

However, the disappearance of the Arctic ice pack would not necessarily be

a blessing to mankind. Although this would open up the Arctic Ocean to shipping, the substitution of open water for 8 million square kilometers of ice pack and the rise of surface temperatures would increase greatly, by evaporation, the water content of the Arctic air. In winter this warmer and moister air would interact with the cold air over the adjacent continents, creating strong cyclones, which would deposit heavier and more frequent snows in coastal areas than now occur. This would increase the size of existing glaciers and cause new ones to form, thus endangering existing communities in the sub-Arctic by creating a new "ice age." Indeed, a theory of ice ages, even for middle latitudes, based on the phenomenon of an open Arctic Ocean, has recently been proposed by Ewing and Donn (*19*).

Equatorial belt. If an increase in outgoing radiation in regions south of latitude 65°N is required to restore the global balance of radiation with respect to sun and space, this would raise the average temperature of these regions from 1.3° to 2.8°C, depending on whether the readjustment is confined to the Northern Hemisphere or includes the Southern Hemisphere, as described earlier. The elevation of the outgoing radiation curve with respect to the incoming radiation curve (which would in the first approximation remain unaffected by the ice cloud but which might change later as the average cloud distribution becomes affected) would draw the "crossover" points of the two radiation curves closer to the equator.

These crossover points are significant because they represent the latitude at which the poleward transports of energy resulting from the excess of solar radiation in the tropics reach their maxima. Since the transport of energy is accomplished mainly by horizontal eddies of the dimensions of cyclones and anticyclones, the equatorward shift of the latitude of maximum transport poleward would mean a corresponding shift equatorward of the eddies responsible for this transport—a wintertime storm characteristic. Furthermore, the amount of energy to be transported would be reduced, so the eddying motion need not be so intense. The trailing fronts of the southerly displaced cyclonic storms would increase the precipitation of the tropical zones.

Middle latitudes. In winter the North Temperate Zone would become warmer and would be located between two dominant storm tracks—one in the sub-Arctic, created by warmer and moister Arctic air masses interacting with cold continental polar air masses and creating more intense storms than normal, and one in the subtropics, having less intense cyclones than normal and displaced a few hundred miles farther south than normal. It would thus appear that the southern portion of the Temperate Zone—say, from latitude 35°N to 50°N —would have less winter precipitation than normal but that the northern portion, from latitude 50°N to 65°N, would have heavier precipitation.

General Remarks

Apart from practical considerations involved in the manufacture and maintenance of a widespread artificial ice cloud over the Arctic, it is of some interest to predict what the meteorological consequences might be.

We need not be satisfied with the mainly qualitative reasoning given here. Recent advances in knowledge of the general circulation of the atmosphere should make it possible in a few years to achieve a more accurate quantitative estimate of the meteorological consequences of an extensive polar ice cloud.

When serious proposals for large-scale weather modification are advanced, as they inevitably will be, the full resources of general-circulation knowledge and computational meteorology must be brought to bear in predicting the results so as to avoid the unhappy situation of the cure being worse than the ailment.

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The Test of Simplicity

Simplicity is a test of the effectiveness of scientific theories; but what is the test of simplicity?

Nelson Goodman

All scientific activity amounts to the invention of and the choice among systems of hypotheses. One of the primary considerations guiding this process is that of simplicity. Nothing could be much more mistaken than the traditional idea that we first seek a true system and then, for the sake of elegance alone, seek a simple one. We are inevitably concerned with simplicity as soon as we are concerned with system at all; for system is achieved just to the extent that the basic vocabulary and set of first principles used in dealing with the given subject matter are simplified. When simplicity of basis vanishes to zero—that is, when no term or principle is derived from any of the others—system also vanishes to zero. Systematization is the same thing as simplification of basis.

Furthermore, in the choice among alternative systems, truth and simplicity are not always clearly distinguishable factors. More often, simplicity is one test of truth. The martyr-bestrewn debate over what bodies in the universe are fixed has turned into the question: What choice of points of reference will give us the simplest description of their relative motions? And by now, after Duhem and Poincaré (*1*), it is almost a commonplace that the refutation of a mode of scientific explanation such as the Ptolemaic or the Newtonian consists not in showing that it is inapplicable but in showing that its application would be intolerably complex.

The case can be put even more strongly. We want to select a system or hypothesis that not only agrees with the established evidence but also predicts correctly the outcome of further observations and experiments. Thus selection of a theory must always be made in advance of the determination of some of the facts it covers; and, accordingly, some criterion other than conformity with such facts must be applied in making the selection. After as many points as we like have been plotted by experiment concerning the correlation of two functions (for example, of time and deterioration of radioactivity), we predict the remaining points by choosing one among all the infinitely many curves that cover the plotted points. Obviously, simplicity of some sort is a cardinal factor in making this choice (we pick the "smoothest" curve). The very validity of the choice depends upon whether the choice is properly made according to such criteria. Thus simplicity here is not a consideration applicable after truth is determined but is one of the standards of validity that are applied in the effort to discover truth.

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Nature of the Problem

But if simplicity is a test of truth and systematization, what is the test of simplicity? Explication of the standards of simplicity constitutes one of the most pressing current problems in the philosophy of science. The scientist, however, may be inclined to ask why there is any *problem* here. Given two alternative systems covering the same subject matter, isn't it always pretty clear which, if either, is the simpler? How does any puzzle arise? There are two good answers.

In the first place, the difficulty and significance of formulating precise general criteria of simplicity no more depend upon trouble encountered in making particular judgments of simplicity than the difficulty and significance of codifying deductive logic depend upon trouble encountered in ordinary reasoning. The systematic logic developed by Aristotle, Boole, Whitehead and Russell (*2*), and others is only incidentally a tool for drawing or correcting inferences needed in ordinary life or in the laboratory. Even the energetic investigation of inductive logic since Mill (*3*) aims much less at providing instructions for making predictions than at eliciting the laws of induction for their own sake. The utility that the results may have for the practicing natural scientist is as much a by-product as the utility that the scientist's results may have for the technologist. Investigation of the canons of deduction or induction or simplicity no more derives its main interest from the help it may give to physicists or biologists than investigation of the laws relating mass and energy derives its main interest from the help it may give to munitions-makers or surgeons.

But in the second place, comparative simplicity is often not very readily and surely judged. Of course if we succeed in deriving one of a set of hypotheses or concepts from the others, the saving is obvious. But comparison of theories incorporating different hypotheses or concepts can offer great difficulty. For example, just when does introduction of the concept of a new fundamental particle simplify and when does it complicate physics? Sometimes different aspects of over-all simplicity may set up competing claims. Is a genuine simplification achieved by deriving mathematics from a few logical concepts at the cost of three big volumes of complicated formulae? We may smugly reply "yes," on the ground that what counts is the simplicity of the basic notions and postulates, and that the derivation is bound to be complicated just to the extent that the basis is simplified. But we seem to take the opposite view when we rate description of the motions of astronomical bodies in terms of ellipses as simpler than that in terms of circles; for the advocate of epicycles might argue that the more elaborate constructions and computations required by his system are the symptomatic result of the greater simplicity of his elementary concepts. If we are tempted to dismiss the idea that circles are simpler than ellipses as a mere superstition, we shall be embarrassed by the fact that, as remarked above, we employ some such notion of the relative simplicity of different curves when we choose one to fit to plotted points in order to extrapolate from determined data to untested cases. Plainly, simplicity is not a single easily estimated characteristic of systems but several different interrelated characteristics, few of them easy to estimate. Thus simplicity is a problem for the scientist as well as for the philosopher. Canons of simplicity need to be formulated not only

for their intrinsic interest but also as means for making needed judgments in actual scientific investigation.

A more plausible excuse for neglecting the study of simplicity has been that the problem, far from being too easy, is hopeless. Simplicity, the argument runs, is vague, ambiguous, variable, and subjective, and therefore too elusive for measurement. But exactly the same argument might have been urged in primitive times against the possibility of measuring temperature or size. Ordinary judgments of size vary with distance, perspective, atmosphere, color, eyesight, and even with interest. Size may mean total bulk, or it may mean maximum diameter, or it may mean height and length and breadth or any of many other quantities. And size changes with temperature, pressure, growth, and wear. The arguments against the measurability of simplicity would, indeed, have been equally strong against the measurability of almost anything. Precision, fixity of meaning, verifiability, and objectivity are the results of measurement, not preconditions of it.

What the problem of simplicity needs is a lot of hard work. So far, just a little has been accomplished; the entire bibliography of contributions to the subject hardly lists more than a dozen items (*4, 5*), most of them published during the past 15 years. Thus the problem is not only one of the most important in the philosophy of science but also one of the newest to be tackled seriously. We are still seeking proper formulation of some aspects of the problem, still exploring avenues of approach to others. Yet this gives the whole matter added interest; for here we can observe philosophy, and therefore science, in the early, formative stages of a typical development from a nebulous cluster of difficulties into articulated questions and on towards an organized discipline.

Simplicity of Basic Terms

We must begin by staking out a very small part of the problem for concentrated attention (*5*). A theory is a system of statements. I shall be concerned here solely with the simplicity of the set of concepts, or the vocabulary of terms, employed in these statements. Furthermore, since some words and symbols—like "and," "or," "not," "if . . . . then," "all," "some," "=," or translations of these—are logical apparatus common to all the systems in question, we need consider only the remaining, extralogical terms. Such of these as are not defined in the system are called "primitive" and constitute the extralogical basis of the vocabulary of the system. It is the simplicity of such extralogical bases that I want to examine here.

Among the extralogical terms of a system may be property-terms like ". . . . is acid," and relation-terms of various degrees, like ". . . . is larger than _____" and ". . . . lies halfway between _____ and _____." The examples given are respectively a one-place, a two-place, and a three-place predicate and may be abbreviated, in standard symbolic notation, as "$A(x)$," "$L(x,y)$," and "$B(x,y,z)$." In general, an n-place predicate has n blanks or variables and stands for an n-adic relation.

Many of the most familiar terms occurring in scientific theories are not predicates but rather nonassertive function-terms, like "the father of . . . .," "the temperature of . . . .," "the distance between . . . . and _____." However, for every function of n arguments there is a corresponding $n+1$-adic relation; and for uniformity, let us suppose that in the extralogical bases under consideration all function-terms have been eliminated in favor of corresponding predicates. Thus the function-term "the father of . . . .," or "f_x," gives way to the predicate "_____ is the father of . . . .," or "$F(x,y)$"; and the function-term "the distance between . . . . and _____," or "$d_{x,y}$," gives way to the predicate "_____ is the distance between . . . . and _____," or "$D_{(x,y,z)}$."

Some predicates, like ". . . . is wooden" and ". . . . is a more ancient fossil than _____," are predicates of things or individuals. Others, like ". . . . are rare" and ". . . . is a subset of _____," are predicates of classes of things. Still others are predicates of classes of classes, numbers, and so on. Some predicates, like ". . . . is the temperature of _____" and ". . . . is a member of _____," are heterogeneous, relating numbers to things, or things to classes, and so forth. To avoid having to deal at the start with differences in simplicity arising from such differences in type, let us require that in every case under consideration all the predicates be of a single homogeneous type—that is, that all apply solely to things, or all apply solely to classes of things, and so on. Our results can afterwards be extended to cover cases where predicates of differing types are involved.

One more temporary assumption is that all predicates in a basis are applicable—that is, that none are like ". . . . is a centaur" or ". . . . is a square circle" in applying to nothing. Although this may seem a common-sense restriction, we may sometimes want to determine the simplicity of a predicate when we are not sure whether it applies to anything. However, the restriction can later be easily removed.

Still further specification of our immediate problem is needed. We are not concerned with the purely grammatical construction of predicates or with their length. Nor are we concerned with their relative familiarity or the ease of comprehending them. These aspects of simplicity and many others may be philosophically and scientifically significant, but our present concern is rather with that logical or structural simplicity of bases which pertains directly to the degree of systematization of theories founded upon them. Just what constitutes such structural simplicity is indeed part of our problem and will have to be made clearer as we proceed. But we may note here that predicates in different languages, or in entirely different words of the same language, or quite unlike in grammatical composition, may be equally simple in this sense, and that for two predicates to apply in exactly the same instances—that is, to have the same denotation or extension—is a sufficient though not necessary condition for their having the same degree of structural simplicity.

In summary, then, we want to find a way of measuring the structural simplicity of the set of undefined extralogical terms of a theory or system. That is, we want to be able to assign to any such set of terms a number that will indicate the complexity of that set and, accordingly, one significant aspect of the complexity of the theory. We begin by assuming that all the terms under consideration are applicable predicates belonging to some one homogeneous type. But they may have any number of places, and of course the several predicates in a given basis need not have the same number of places.

A Clue to an Answer

The first step toward measuring the size of objects must have been to fix upon a single elementary clue: the application of a yardstick of some sort directly to the object in a certain way. This at once abstracted from apparent differences resulting from variations in distance and perspective, picked out as standard certain among the innumerable

dimensions of familiar objects, and provided a unit for the numerical expression of size. We seek some comparable clue to the problem of measuring the simplicity of extralogical bases.

From the primitive predicates constituting the extralogical basis of a system, with the help of the specified logical apparatus, all other extralogical terms of the system are generated by definition. One might first think of measuring complexity by definitional yield, or defining-power, on the principle that if one set of predicates is definable from a second but the second is not definable from the first, then the second is more complex, and that interdefinable sets of predicates are equally complex. For example, we can define "... differs by one from ____," among the natural numbers, from "... is the immediate successor of ____" (as follows: "x differs by one from y if and only if x is the immediate successor of y, or y is the immediate successor of x") but not vice versa; hence a basis consisting solely of the former predicate would be rated simpler, according to this proposal, than a basis consisting solely of the latter predicate. Yet, plausible as this idea may be in a few such cases, it is quite mistaken as a general principle, for it would have the consequence that no simpler basis could be found for a system than that arrived at by merely taking all the extralogical terms of the system as primitive! For, since any adequate basis for a system must yield, through definition, all the terms of the system, the set of all these terms would, by the proposed criterion, be as simple as any adequate basis of fewer of these predicates. What is actually maximal complexity would be accounted maximal simplicity.

Counting the predicates in a basis seems, offhand, a better test of simplicity, but this likewise fails. For if the number of predicates in a basis were the sole measure of complexity, ultimate simplicity would always be achieved in a purely trivial way. Any number of predicates can be readily combined, so to speak, into a single predicate. A basis consisting of a one-place predicate (say "... is copper") and a two-place predicate (say, "____ is more durable than ....") can always be replaced by a single three-place predicate (say, "... is copper, and ____ is more durable than ...."). And, taking all the predicates in a system, we can immediately construct a single many-place predicate from which all are definable by a routine procedure. If the total number of places in those original predicates is m, the single primitive thus arrived at will have m places. Obviously, no genuine increase in simplicity is effected in this way; many simpler predicates are replaced by a single correspondingly more complex one. The proposal to measure the complexity of bases by a mere counting of the predicates they contain fatally ignores all differences of complexity among predicates.

The idea that inevitably suggests itself next is to measure complexity by the total number of places in all the predicates in a basis. The spurious simplicity effected by artificially combining several predicates into one will thus be properly discounted. But the new proposal is again too hasty. While we have clear grounds for not regarding an m-place predicate as simpler than a set of several predicates with a total of m places, we have no such grounds for not regarding the set of predicates as simpler than the single predicate. Replacement of set by single predicate is always possible, but not replacement of single predicate by set. For example, the two one-place predicates "... is a parent" and "... has a parent" will not serve instead of the two-place predicate "... is a parent of ...."; to say that x is a parent and y has a parent is not to say that x is a parent *of* y. The complexity of bases seems to vary not only with the number of places but also in some manner with the way this number is distributed among predicates in the basis. Several plausible formulas for this variation can easily be devised, but there is no immediately obvious method for choosing among them.

Not only have our efforts been unsuccessful so far, but trying out one rule of thumb after another begins to look like an unpromising method of attacking our problem. Yet, all the time, the clue we want has lain ready in our hands. In rejecting the mere counting of primitives as a measure of complexity, we argued that any set of predicates can always be replaced by a single predicate. We tacitly appealed to the principle that replacement of a basis by another effects no genuine simplification where such a replacement can always be made by a purely routine procedure. Other applications of the same principle come quickly to mind. Predicates can always be added to a basis without destroying its adequacy, and a predicate can always be replaced by another having more places; obviously, in neither case is simplicity increased. In other words, an elementary principle applied in judging proposed measures of complexity is this: If every basis like a given one can always be replaced by some basis like a second, then the first is not more complex than the second. This may seem too meagre and negative a principle to carry us very far, but it is the key to our problem. More carefully formulated, clarified, and supplemented, it will constitute the fundamental axiom of a calculus of simplicity.

First Axioms of Simplicity

Let us, then, adopt as our first postulate:

P1. *If every basis of a relevant kind K is always replaceable by some basis of a relevant kind L, then K is not more complex than L* (that is, K does not have a higher complexity value than L—or, briefly, when "v" stands for "the complexity-value of," $vK \leq vL$).

Now a good many points here call for explanation. In the first place, to say that every basis of kind K is *always replaceable* by some basis of kind L is to say not only that there always is some equivalent basis of kind L but also that we can always find one; that is, that given any basis B of kind K, with no further information than that B is of kind K, we can define in terms of B and the stated logical apparatus alone some basis B' of kind L such that we can redefine B from B' and the logic alone.

In the second place, our postulate speaks of the complexity of kinds rather than of bases. A kind has the highest complexity-value possessed by any basis of that kind, and a basis has the complexity-value of the narrowest relevant kind to which the basis belongs.

In the third place, what are the *relevant kinds*? Structural kinds, certainly, since we are concerned with structural complexity. But not every structural difference constitutes a difference in relevant kind; for if that were the case, then, since definition from a basis always depends upon structural features, our postulate would in effect reduce to the test in terms of defining power that we have already rejected. What will constitute a relevant kind depends upon the fact that our postulate is intended to express the principle that *purely routine* replacement effects no genuine simplification.

Now, replacement of a basis B by another, B', is purely routine if every basis like B, or of the same broad sort or gen-

eral kind as B, is always replaceable by some basis of the same general kind as B'. The ordinary notion of a "broad sort" or "general kind" is vague and has to be supplanted by something much more clear-cut. As a first approximation, we may define such a relevant kind as any class of bases delimited by specifying the number of predicates in a basis and the number of places in each predicate, together with any or no information concerning the three most commonplace properties of predicates: reflexivity, transitivity, and symmetry. (At the moment, the reader need not understand what these properties are; they will be explained presently, and our tentative definition of relevant kinds will be somewhat revised). Thus, for example, the class of all bases consisting of a two-place and a one-place predicate is a relevant kind; so also is the narrower class of bases consisting of a symmetric two-place predicate and a one-place predicate. Our tentative definition of relevant kinds will presently be further explained and somewhat revised.

One may ask what justifies this particular interpretation of "broad sort" or "general kind," this particular decision in spelling out the imprecise notion of purely routine replacement. Quite plainly, no precise interpretation can claim to be uniquely indicated. Developing any method of measurement is a process of forging a sharp and effective tool from rough practice. We must look to the practice where it offers us guidance and, at the same time, remove obscurities, resolve conflicts, and fill in gaps, by rulings designed to yield the most significant results. A method of measuring anything must meet taxing but somewhat elusive demands of faithfulness and serviceability, but no method is exclusively correct. Thus our chosen definition of relevant kinds must find its justification in the combination of its plausibility as a translation of the rough notion of "general kinds" with the overall acceptability of the calculus of measurement to which this interpretation is a contributing factor.

From postulate 1, we can show that two kinds are equally complex if every basis of each kind is always replaceable by some basis of the other kind, and we can derive complexity-value equations for many kinds of bases. But in order to derive inequalities—to show that certain kinds are more complex than certain others—we need something more. This is provided by a prosaic postulate to the effect that a basis consisting of some predicates is more complex than a basis consisting of none, and that the value of a basis can be computed by adding the complexity-values of the predicates in it.

P2. *Every predicate in an extralogical basis has a positive complexity-value, and the value of the basis is the sum of the values of the predicates in it.*

The second clause operates to exclude from consideration, in determining complexity-values, any interconnections among the predicates in a basis. But such interconnections will be taken into account later, after a primary scale of complexity-values has been established.

Development of a Calculus

Easily proved from these postulates are certain elementary theorems, such as that *where m is less than n, the complexity-value of the class of m-place predicates* (that is, of the kind of basis that consists of a single m-place predicate) (6) *is less than the complexity-value of the class of n-place predicates.* But the further development of the calculus requires treatment of more specific properties of predicates and becomes highly complicated. I shall describe it here very sketchily, merely to suggest its general character and the results obtained.

1) Two-place predicates are *irreflexive* if they never relate anything to itself. Thus, "____ is a parent of ____" is irreflexive. On the other hand, the predicate "____ has the same blood type as ____" is reflexive, since everyone has the same blood type as himself. Some predicates, like "____ has a brother in common with ____," are neither reflexive nor irreflexive; every person with a brother, but no person without, has a brother in common with himself. One-place predicates are, degenerately, both reflexive and irreflexive.

Reflexive predicates are interreplaceable with irreflexive predicates and hence they are equal in complexity. A two-place predicate "P" that is neither reflexive nor irreflexive has the same complexity-value as a set of two irreflexive predicates: a two-place predicate that relates every two distinct elements, x and y, related by "P," and a one-place predicate applying to every x that "P" relates to x itself.

With predicates of more than two places, the varieties of reflexivity-properties multiply rapidly, for a many-place predicate may be reflexive or irreflexive or nonreflexive with respect to all or to any given selection of its places. But fortunately, *the complexity of any basis can be proved to be equal to that of a certain basis consisting solely of thoroughly irreflexive predicates* (that is, irreflexive with respect to all their places). Every other predicate of n places in the basis gives way to a set of one or more thoroughly irreflexive predicates, each having not more than n places. Thus we can confine our attention to thoroughly irreflexive predicates.

2) A two-place predicate, like "____ is greater than ____," is said to be *transitive,* since if x is greater than y and y is greater than z, then x is greater than z. However, transitivity proves to be less pertinent to complexity measurement than (and is now to be supplanted as a defining property of relevant kinds by) a stronger property of predicates that may be called *self-completeness.* If two one-place predicates—say, "____ is red" and "____ is white"—are compounded into one two-place predicate—say, "____ is red, and ____ is white"—the latter is self-complete. In general, a self-complete two-place predicate is such that if it joins x to y and also z to w (and if all these except possibly y and z are different), then it joins x to w. Predicates of more places may likewise be self-complete with respect to all their places: for example, the predicate "____ is red, and ____ is white, and ____ is square." Such predicates (whatever their number of places) are, figuratively, rather unstable; they break down easily into one-place predicates. For that reason, thoroughly self-complete predicates do not often occur in actual systems; but for the same reason, their consideration is important for our present purposes. Their resolubility enables us to show that *the complexity-value of an n-place thoroughly self-complete predicate is equal to the complexity-value of n one-place predicates.* This is a crucial step towards determination of the general relationship between the complexity-values of predicates differing in number of places.

3) A two-place predicate is *symmetric* if it pairs elements in both directions whenever it pairs them in either; for example, "____ is a sibling of ____" is symmetric, since everyone is a sibling of anyone he or she has as a sibling. The three-place predicate "____ and ____ and ____ are triplets" is also symmetric with respect to all its places, and a predicate of more places that is simi-

larly entirely order-indifferent is likewise thoroughly symmetric.

We saw that a self-complete two-place predicate has the same complexity-value as two one-place predicates; but a *symmetric* self-complete two-place predicate has the same value as a *single* one-place predicate. Such a predicate merely pairs in both directions every two elements of a set. Likewise, *an n-place thoroughly symmetric and thoroughly self-complete predicate* merely combines in all directions (or applies to all permutations of) every n elements of a set, and such an n-place predicate *has the same complexity-value as a single one-place predicate.*

4) Complications pile up fast when we consider predicates that are only partially, rather than thoroughly, self-complete or symmetric. For instance, many-place predicates may be symmetric with respect to some rather than all of their places. If x lies on a straight line between y and z, it follows that x lies on a straight line between z and y, but not that y lies on a straight line between x and z. Thus the three-place predicate "... lies on a straight line between ——— and ....." is symmetric with respect to the last two, but not with respect to all, of its places.

Again, a predicate may be symmetric with respect to sequences of its places rather than with respect to its places severally. For example, if x is exactly as much greater than y as w is greater than z, then w is also exactly as much greater than z as x is greater than y. The four-place predicate in question here is not symmetric with respect to any two or more of its places severally but is symmetric with respect to pairs of its places: the pair of its first two and the pair of its last two places.

Similarly, self-completeness may occur with respect to sequences of places rather than with respect to places severally. And a single predicate may exhibit many varieties of symmetry and self-completeness at once.

All this makes the full treatment of our problem very intricate. Briefly, what we do is define the *symmetry index* of a predicate as a certain function of all the symmetries the predicate has, and also define the *self-completeness index* of a predicate in a comparable way. We then examine how complexity varies in relation to these indices.

5) This examination, carried out with the help of two supplementary postulates, yields the means for determining the complexity-value of any relevant kind of basis as a function of two constants (either but not both of which may occur vacuously): the complexity-value of one-place predicates and the complexity-value of two-place irreflexive predicates. In order to achieve a fully quantitative measure, a final postulate is needed to fix the numerical value of these constants. This postulate stipulates that all, and only, those kinds of bases that can be shown by preceding postulates to have the same value as one-place predicates shall have the value 1, and that all other kinds shall have the lowest integral value consistent with this requirement and with preceding postulates. Assignment of the value 1 is a mere convenience; we might have used some arbitrary constant c. The choice of integral values is always indicated in any scheme of measurement where, as here, use of nonintegral values can be avoided.

Resultant Simplicity Formulae

Some of the resulting complexity-values are given by the following formulae:

1) The class of n-place thoroughly irreflexive predicates has value $2n - 1$.

2) The class of n-place thoroughly irreflexive and thoroughly self-complete predicates has the value n.

3) The class of n-place thoroughly irreflexive and thoroughly symmetric predicates has the value n.

4) The class of n-place predicates that are thoroughly irreflexive, self-complete, and symmetric has the value 1.

More generally, *the value of any kind of n-place irreflexive predicate is $2n - 1$ minus the sum of its symmetry and self-completeness indices.*

When the limitation to irreflexive predicates is dropped, the values of relevant kinds are obtained, as suggested earlier, by computing the value of corresponding kinds of bases consisting of irreflexive predicates. These values rise very rapidly with the number of places; the class of all two-place predicates has the complexity-value 4, and that of all three-place predicates, the value 15.

Some temporary exclusions made earlier can now be removed. In the first place, the restriction to applicable predicates is easily eliminated without affecting any of our results; for since inapplicable predicates have zero complexity, adding them to a relevant kind cannot increase its complexity-value. In the second place, where the predicates in question are not all of one homogeneous type (but meet certain conditions of finitude), available methods of correlating each predicate with a set of predicates of the lowest type may be applied, and the complexity-values may then be readily calculated. Finally, our temporary exclusion from consideration of interconnections between predicates is compensated for by adoption of a secondary rule for choosing in certain cases between bases of different structure but of equal computed complexity-value.

Present Status of Simplicity Study

The calculus I have outlined is virtually complete; proofs for all theorems are currently being checked. However, some possibilities for improvement still need consideration, and other writers have entered some objections and have proposed modifications and alternatives (*7*). Investigation of the measurement of the structural simplicity of the extralogical bases of theories is unlikely to reach its stage of ultimate stagnation for some time. But that can also be said of many an older scientific inquiry. I hope enough has been said to show that our problem has at least been carried some steps away from its stage of initial confusion.

We have been dealing, it must be remembered, with a very small corner of the big problem of simplicity. We have considered the simplicity of terms but not of postulates framed in these terms. We still have no measure of the over-all simplicity of theories. Nor does our calculus answer the crucial questions involved in the fitting of curves and in induction generally (*8*). But perhaps the progress made on one aspect of the problem will somewhat alleviate despair concerning the rest. If some of the remaining questions seem too vague to be amenable to precise formulation and treatment, we may well reflect that most scientific problems seemed that way once. The obscurities of problems are due less to the subject matter than to short-comings in its investigation.

References and Notes

1. P. Duhem, *Système du Monde* (Paris, 1913); H. Poincaré, *Science et Methode* (Paris, 1908).
2. G. Boole, *An Investigation into the Laws of Thought* (London, 1854); A. N. Whitehead and B. Russell, *Principia Mathematica* (Cambridge, England, 1910–1913).
3. J. S. Mill, *A System of Logic* (London, 1843).
4. The articles mentioned in reference 5 together contain a fairly complete listing of relevant publications, from an article by Lindenbaum in 1935 to the present: Karl Popper's discussion in *Logik der Forschung* (Vienna, 1935) should be added to the list.
5. The treatment of simplicity to be outlined here

has been developed in the course of several of my publications, beginning with "On the simplicity of ideas" [*J. Symbolic Logic* 8, 107 (1943)] and including chapter 3, sections 3–7, of *The Structure of Appearance* [Harvard Univ. Press, Cambridge, Mass., 1951]. The most recent articles, and those most closely followed here, are "Axiomatic measurement of simplicity" [*J. Philosophy* 52, 709 (1955)] and "Recent developments in the theory of simplicity," in *Philosophy and Phenomenological Research*, in press.

6. I shall often abbreviate such a locution as "the complexity-value of the kind of basis that consists of one two-place predicate" to "the complexity-value of two-place predicates" or to "the complexity-value of a two-place predicate."

7. A discussion of these will appear in "Recent developments in the theory of simplicity," in *Philosophy and Phenomenological Research*, in press.

8. On this topic, see I. Scheffler, "Inductive inference: A new approach" [*Science* 127, 177 (1958)] and N. Goodman, *Fact, Fiction, and Forecast* (Harvard Univ. Press, Cambridge, Mass., 1955).

Richard Goldschmidt, Biologist

On 12 April 1958, Richard Goldschmidt was 80 years old. He was recovering from a nearly fatal illness which had struck a few weeks earlier. Letters from friends and well-wishers arrived from many lands, praising his achievements as a biologist, a zoologist, and a geneticist, expressing amazed admiration for his continued scientific productivity, and professing warm personal feelings of affection. That birthday, quietly spent with his family, was a happy day in a period of years in which physical pain and fear that the body might force the mind into inactivity were ever-present. Less than two weeks later, on 24 April, the end came.

Richard Goldschmidt's ancestors belonged to respected families who had lived for centuries in Frankfurt am Main. He received an excellent education at the Gymnasium and at an early age decided to become a naturalist. In 1896 he entered the University of Heidelberg where, to use his own words, he "had such glorious teachers as Bütschli, Gegenbaur, Kühne, V. Meyer, Kossel, Rosenbusch." After a short period in Munich under Richard Hertwig, he returned to Heidelberg and obtained the Ph.D. degree in 1902. From 1903 to 1913 he worked and taught in Munich. In 1914 Goldschmidt was selected by Boveri to join him as a member of "the newly founded . . . wonderful Kaiser Wilhelm Institut für Biologie, Berlin-Dahlem." Soon after, for reasons of health, Boveri had to give up his projected move to the Institut. Goldschmidt accepted his appointment, which extended over 22 years; for the last 15 of these he served as a director. In 1936, after the passage of the "Nürnberg Laws," he was invited to join the zoology department of the University of California. "This turned out to be one of the most happy events of my life, crowned by becoming an American citizen in 1942"—thus he wrote in an autobiographical sketch filed, by request, with the National Academy of Sciences in Washington (1948). By then he had, according to American custom, included a middle name in the by-line of his publications—Richard Benedict Goldschmidt.

In Berkeley he taught genetics and cytology for more than a decade and uninterruptedly continued his research for 22 years. Reports on experiments and books on wide-ranging subjects followed one another. Even after his death two papers appeared in print.

Goldschmidt's work covers nearly 60 years of tireless productivity. When, in 1954, he compiled a list of his 17 books and approximately 250 papers, he divided the latter into the following classes: protozoology (1904–07); cytology (1902–50); embryology (1900–35); histology and neurology (1903–10); acrania (1905–33); gynandromorphism (1922–37); intersexuality (1911–51); general sex determination, sex-controlled heredity (1910–53); genetics and evolution (1911–53); genetics: Mendelian analysis and general (1913–54); physiological genetics (1916–52); human heredity (1927–53); biographical, popular science, *varia* (1916–53).

He listed his books under "technical," "textbooks," "popular," and "travel." Among these were such books as *Die quantitativen Grundlagen von Vererbung und Artbildung* (1920); *Mechanismus und Physiologie der Geschlechtsbestimmung* (1920); *Physiologische Theorie der Vererbung* (1927); *Die sexuellen Zwischenstufen* (1931); *Physiological Genetics* (1938); *The Material Basis of Evolution* (1940); *Theoretical Genetics* (1955); *Einführung in die Vererbungswissenschaft* (first edition, 1911; fifth edition, 1928); *Ascaris, eine Einführung in die Wissenschaft vom Leben* (first edition, 1921; third edition, 1953); and *Neu-Japan* (1927). Translations of his books appeared in English, French, Hebrew, Japanese, Polish, Russian, Spanish, and Yugoslavian. His latest volume, the charming *Portraits from Memory, Recollections of a Zoologist* (1956), is in the process of being translated into German. An autobiography went to press this spring.

Goldschmidt's influence on the biology of the 20th century rested on observation and experiment as well as on the theory-building sweep of his imagination. His outstanding experimental accomplishment was the long series of crosses between geographical races of the gypsy-moth *Lymantria*. It led to an analysis of the phenomenon of intersexuality which went far beyond the framework of classical genetics. He had early trained himself to be a revolutionary of science. He reached his height in his endeavors to build a dynamic physiological genetics on the static and material basis which Mendel and Morgan had laid, and which he admired, as such, without reservation. He raised his voice in warning of a too ready acquiescence in apparently established concepts of the gene and some widely held genetic interpretations of evolution. He was willing to face the strong opposition to his unpopular ideas, but he lived to see them move into the forefront of contemporary thought.

He lectured before thousands of eager listeners—students, colleagues, men of other professions, and interested lay people—in Europe, America, Asia, and Australia. Three periods which he spent

in Japan were historic events in the history of genetics of that country. Among his students, pre- or post-doctoral, were men and women like Buchner, Rhoda Erdmann, Gardner, Aloha Hannah-Alava, Masui, Minouchi, Nachtsheim, Popoff, Seiler, and Süffert. In a wider sense, the circle of his disciples encompasses biologists everywhere.

Goldschmidt's interests went greatly beyond his "beloved zoology." Until middle age he excelled in various sports. He molded his life after Goethe, and, only recently, he and his wife systematically read again all of Goethe's works. His main avocation was that of a connoisseur and collector of art. The home which he and Mrs. Goldschmidt created became a treasure house of paintings, statues, and other objects, each of which had been acquired with love and insight. The art of the Orient was his particular area of pleasure and understanding. The many visitors whom Mrs. Goldschmidt and he welcomed gained lasting impressions from these occasions.

The life of Richard Goldschmidt was woven into the framework of his time. As a young man he served in the army of his native country. When World War I kept him in the United States, where he had come from Japan, he at first enjoyed the hospitality of American scientific institutions, but, when America entered the war, his professed loyalty to Germany led to his internment as an enemy alien. When, in 1919, he returned to the Kaiser Wilhelm Institut, he soon rose to a commanding position among the great scientists who upheld the tradition of intellectual achievement of their country. When that tradition broke, in 1933, he had to prepare to leave Germany, to build up anew his life's activities, and to take root again in a different country. Bitter, he resumed his tasks at the age of 58. His reception in America, though warm in a personal way, was cold, scientifically. The breadth of his biological wisdom was appreciated little, and the iconoclasm of his views was regarded as the irritating fancy of a man

Richard Goldschmidt

of the past. But slowly recognition came again. Following the numerous honors which had earlier been Richard Goldschmidt's share, his election to the National Academy occurred in 1947, when he was 69 years old. In 1950 the Genetics Society of America celebrated the "Golden Jubilee of Genetics," and Goldschmidt was asked to give the opening address. The Cold Spring Harbor Symposium on Genes and Chromosomes, in 1951, chose him as the first speaker. In 1953 he was elected president of the 9th International Congress of Genetics in Bellagio.

A reconciliation came in his attitude to Germany. He had never broken the bonds of personal friendship, and he and his wife had sent many CARE and other packages to the devastated postwar country. While he could not bring himself to visit his homeland again, he was willing to accept, on the occasion of his 75th birthday, honorary membership in the Deutsche Zoologische Gesellschaft and an honorary degree from the Freie Universität Berlin. And in his last year he addressed a German audience when he spoke, with his Frankfurt accent, over the Süddeutsche Rundfunk on "Aus der Geschichte der Vererbungswissenschaft."

He never attained old age. He could have been the grand old man of more than a half century of biology—and yet he never was given that retrospective title. People corresponded with him and visited him as the contemporary leader.

He knew his worth—how could he help it! He openly, and with relish, leveled his critique against those whose views he opposed. Only a few years ago he chose the pungent title "Pricking a bubble" for a polemic. But he could also write about his nonconformist views under the modest title "Evolution, as viewed by one geneticist." He charmed his adversaries, when he met them in person, with his ability to divorce the intellectual points of divergence from the appreciation of the fellow scientist. He inspired awe by his achievements and by his often forbidding appearance. Yet his kindness and solicitude became apparent to those who approached him. His assistants he treated as fellow scientists. To his friend the late Oberpräparator Aigner, he dedicated a paper in *Naturwissenschaften*. "In Ph.D. examinations," one colleague wrote him, "we depended on you to bring forth the most favorable side of the candidates' performance, and I always thought of you as the aspiring students' 'Advokat.'" Another letter read: "How impressed I was [on the boat to Stockholm in 1948] with your thoughtful interests in us young unknowns!!" "The guardian angel of the small people" he was called in 1927.

Richard Goldschmidt made his existence into a work of art. It had the classical features of comprehensiveness, depth, and achievement. It had the modern features of expressionism where emphasis broke the bounds of beauty conceived too narrowly. Like any mortal, he did not attain perfection—nor did he aspire to it. Like few mortals, he achieved greatness.

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Note

This biographical sketch appears simultaneously in *Experientia*.

News of Science

War Prevention and International Cooperation: Statement of Third Pugwash Conference of Nuclear Scientists, Austria, 14–21 September

Necessity to End Wars

We meet in Kitzbuhel and in Vienna at a time when it has become evident that the development of nuclear weapons makes it possible for man to destroy civilization and, indeed, himself; the means of destruction are being made ever more efficient. The scientists attending our meetings have long been concerned with this development, and they are unanimous in the opinion that a full-scale nuclear war would be a world-wide catastrophe of unprecedented magnitude.

In our opinion defense against nuclear attack is very difficult. Unfounded faith in defensive measures may even contribute to an outbreak of war.

Although the nations may agree to eliminate nuclear weapons and other weapons of mass destruction from the arsenals of the world, the knowledge of how to produce such weapons can never be destroyed. They remain for all time a potential threat for mankind. In any future major war, each belligerent state will feel not only free but compelled to undertake immediate production of nuclear weapons; for no state, when at war, can be sure that such steps are not being taken by the enemy. We believe that, in such a situation, a major industrial power would require less than one year to begin accumulating atomic weapons. From then on, the only restraint against their employment in war would be agreements not to use them, which were concluded in times of peace. The decisive power of nuclear weapons, however, would make the temptation to use them almost irresistible, particularly to leaders who are facing defeat. It appears therefore that atomic weapons are likely to be employed in any future major war with all their terrible consequences.

It is sometimes suggested that localized wars, with limited objective, might still be fought without catastrophic consequences. History shows, however, that the risk of local conflicts growing into major wars is too great to be acceptable in the age of weapons of mass destruction. Mankind must therefore set itself the task of eliminating all wars, including local wars.

Requirements for Ending the Arms Race

The armaments race is the result of distrust between states; it also contributes to this distrust. Any step that mitigates the arms race, and leads to even small reductions in armaments and armed forces, on an equitable basis and subject to necessary control, is therefore desirable. We welcome all steps in this direction and, in particular, the recent agreement in Geneva between representatives of East and West about the feasibility of detecting test explosions. As scientists, we take particular pleasure in the fact that this unanimous agreement, the first after a long series of unsuccessful international disarmament negotiations, was made possible by mutual understanding and a common objective approach by scientists from different countries. We note with satisfaction that the governments of the U.S.A., U.S.S.R., and U.K. have approved the statements and the conclusion contained in the report of the technical experts. This is a significant success; we most earnestly hope that this approval will soon be followed by an international agreement leading to the cessation of all nuclear weapon tests and an effective system of control. This would be a first step toward the relaxation of international tension and the end of the arms race.

It is generally agreed that any agreement on disarmament and in particular nuclear disarmament, requires measures of control to protect every party from possible evasion. Through their technical competence, scientists are well aware that effective control will in some cases be relatively easy, while it is very difficult in others. For example, the conference of experts in Geneva has agreed that the cessation of bomb tests could be monitored by a suitable network of detecting stations. On the other hand, it will be a technical problem of great difficulty to account fully for existing stocks of nuclear weapons and other means of mass destruction. An agreement to cease production of nuclear weapons presents a problem of intermediate technical difficulty between these two extreme examples.

We recognize that the accumulation of large stocks of nuclear weapons has made a completely reliable system of controls for far-reaching nuclear disarmament extremely difficult, perhaps impossible. For this disarmament to become possible, nations may have to depend, in addition to a practical degree of technical verification, on a combination of political agreements, of successful international security arrangements, and of experience of successful cooperation in various areas. Together, these can create the climate of mutual trust, which does not now exist, and an assurance that nations recognize the mutual political advantages of avoiding suspicion.

Recognizing the difficulties of the technological situation, scientists feel an obligation to impress on their peoples and on their governments the need for policies which will encourage international trust and reduce mutual apprehension. Mutual apprehensions cannot be reduced by assertions of good will; their reduction will require political adjustment and the establishment of active cooperation.

What War Would Mean

Our conclusions about the possible consequences of war have been supported by reports and papers submitted to our Conference. These documents indicate that if, in a future war, a substantial proportion of the nuclear weapons already manufactured were delivered against urban targets, most centres of civilization in the belligerent countries would be totally destroyed, and most of their populations killed. This would be true whether the bombs used derived most of their power from fusion reactions (so-called "clean" bombs) or principally from fission reactions (so-called "dirty" bombs). In addition to destroying major centres of population and industry, such bombs would also wreck the economy of the country attacked, through the destruction of vital means of distribution and communication.

Major states have already accumulated large stocks of "dirty" nuclear weapons; it appears that they are continuing to do so. From a strictly military point of view, dirty bombs have advantages in some situations; this makes likely their use in a major war.

The local fall-out resulting from extensive use of "dirty" bombs woud cause the death of a large part of the population in the country attacked. Following their explosion in large numbers (each explosion equivalent to that of millions of tons of ordinary chemical explosive), radioactive fall-out would be distributed, not only over the territory to which they were delivered but, in varying intensity, over the rest of the earth's surface. Many millions of deaths would thus be produced, not only in belligerent but also in

non-belligerent countries, by the acute effects of radiation.

There would be, further, substantial long-term radiation damage, to human and other organisms everywhere, from somatic effects such as leukemia, bone cancer, and shortening of the life span; and from genetic damage affecting the hereditary traits transmitted to the progeny.

Knowledge of human genetics is not yet sufficient to allow precise predictions of consequences likely to arise from the considerable increase in the rate of mutation which would ensue from unrestricted nuclear war. However, geneticists believe that they may well be serious for the future of a surviving world population.

It is sometimes suggested that in a future war, the use of nuclear weapons might be restricted to objectives such as military bases, troop concentrations, airfields, and other communication centres; and that attacks on large centres of population could thus be avoided.

Even tactical weapons now have a large radius of action; cities and towns are commonly closely associated with centres of supply and transportation. We, therefore, believe that even a "restricted" war would lead, despite attempted limitation of targets, to widespread devastation of the territory in which it took place, and to the destruction of much of its population. Further, an agreement not to use cities for military purposes, entered into in order to justify their immunity from attack, is unlikely to be maintained to the end of a war, particularly by the losing side. The latter would also be strongly tempted to use nuclear bombs against the population centres of the enemy, in the hope of breaking his will to continue the war.

Hazards of Bomb Tests

At our first conference it had been agreed that while the biological hazards of bomb tests may be small compared with similar hazards to which mankind is exposed from other sources, hazards from tests exist and should receive close and continued study. Since then, an extensive investigation by the United Nations Scientific Committee on the Effects of Atomic Radiation has been carried out and its authoritative conclusions published. In this case, too, scientists from many different countries have been able to arrive at a unanimous agreement. Their conclusions confirm that the bomb tests produce a definite hazard and that they will claim a significant number of victims in present and following generations. Though the magnitude of the genetic damage appears to be relatively small compared with that produced by natural causes, the incidence of leukemia and bone cancer due to the radioactivity from test explosions may, in the estimate of the U.N. committee, add significantly to the natural incidence of these diseases. This conclusion depends on the assumption (not shared by all authorities in the field) that these effects can be produced even by the smallest amount of radiation. This uncertainty calls for extensive study and, in the meantime, for a prudent acceptance of the most pessimistic assumption. It lends emphasis to the generally agreed conclusion that all unnecessary exposure of mankind to radiation is undesirable and should be avoided.

It goes without saying that the biological damage from a war, in which many nuclear bombs would be used, would be incomparably larger than that from tests; the main immediate problem before mankind is thus the establishment of conditions that would eliminate war.

Science and International Cooperation

We believe that, as scientists, we have an important contribution to make toward establishing trust and cooperation among nations. Science is, by long tradition, an international undertaking. Scientists with different national allegiances easily find a common basis of understanding: they use the same concepts and the same methods; they work toward common intellectual goals, despite differences in philosophical, economic, or political views. The rapidly growing importance of science in the affairs of mankind increases the importance of the community of understanding.

The ability of scientists all over the world to understand one another, and to work together, is an excellent instrument for bridging the gap between nations and for uniting them around common aims. We believe that working together in every field where international cooperation proves possible makes an important contribution toward establishing an appreciation of the community of nations. It can contribute to the development of the climate of mutual trust, which is necessary for the resolution of political conflicts between nations, and which is an essential background to effective disarmament. We hope scientists everywhere will recognize their responsibility, to mankind and to their own nations, to contribute thought, time, and energy to the furthering of international cooperation.

Several international scientific undertakings have already had considerable success. We mention only the century-old, world-wide cooperation in weather science, the two International Polar Years which preceded (by seventy-five and twenty-five years respectively), the present International Geophysical Year, and the Atoms-for-Peace Conferences. We earnestly hope that efforts will be made to initiate similar collaboration in other fields of study. Certainly they will have the enthusiastic support of scientists all over the world.

We call for an increase in the unrestricted flow of scientific information among nations, and for a wide exchange of scientists. We believe that nations which build their national security on secrecy of scientific developments sacrifice the interests of peace, and of the progress of science, for temporary advantages. It is our belief that science can best serve mankind if it is free from interference by any dogma imposed from the outside, and if it exercises its right to question all postulates, including its own.

Technology in the Service of Peace

In our time, pure and applied science have become increasingly interdependent. The achievements of fundamental, experimental and theoretical science are more and more rapidly transformed into new technological developments. This accelerated trend is manifest, alike in the creation of weapons of increased destructiveness, and in the development of means for the increased wealth and well-being of mankind. We believe that the tradition of mutual understanding and of international cooperation, which have long existed in fundamental science, can and should be extended to many fields of technology. The International Atomic Energy Agency, for example, aims not merely at cooperation for establishing facts about atomic energy, but also at helping the nations of the world to develop a new source of energy as a basis for the improvement of their material welfare. We believe that international cooperation in this and other fields, such as economic development and the promotion of health, should be greatly strengthened.

The extremely low level of living in the industrially underdeveloped countries of the world is and will remain a source of international tension. We see an urgent need to forward studies and programs for the effective industrialization of these countries. This would not only improve the level of living of the majority of the population of the world; it would also help reduce the sources of conflict between the highly industrialized powers. Such studies would offer fruitful scope for cooperative efforts between scientists of all nations.

The great increase in the ease and speed of communications, and our increasing understanding of how the forces of nature influence the living conditions of nations in different parts of the world, show us, in a way not previously possible, the extent to which the prosperity of individual nations is connected with, and dependent upon, that of mankind as a whole; and how rapidly it could be

increased by common international effort. We believe that through such common effort, the coexistence between nations of different social and economic structure can become not merely peaceful and competitive, but to an increasing degree cooperative, and therefore more stable.

As scientists, we are deeply aware of the great change in the condition of mankind which has been brought about by the modern development and application of science. Given peace, mankind stands at the beginning of a great scientific age. Science can provide mankind with an ever-increasing understanding of the forces of nature, and the means of harnessing them. This will bring about a great increase in the well-being, health, and prosperity of all men.

The Responsibility of Scientists

We believe it to be a responsibility of scientists in all countries to contribute to the education of the peoples by spreading among them a wide understanding of the dangers and potentialities offered by the unprecedented growth of science. We appeal to our colleagues everywhere to contribute to this effort, both through enlightenment of adult populations, and through education of the coming generations. In particular, education should stress improvement of all forms of human relations and should eliminate any glorification of war and violence.

Scientists are, because of their special knowledge, well equipped for early awareness of the danger and the promise arising from scientific discoveries. Hence, they have a special competence and a special responsibility in relation to the most pressing problems of our times.

In the present conditions of distrust between nations, and of the race for military supremacy which arises from it, all branches of science—physics, chemistry, biology, psychology—have become increasingly involved in military developments. In the eyes of the people of many countries, science has become associated with the development of weapons. Scientists are either admired for their contribution to national security, or damned for having brought mankind into jeopardy by their invention of weapons of mass destruction. The increasing material support which science now enjoys in many countries is mainly due to its importance, direct or indirect, to the military strength of the nation and to its degree of success in the arms race. This diverts science from its true purpose, which is to increase human knowledge, and to promote man's mastery over the forces of nature for the benefit of all.

We deplore the conditions which lead to this situation, and appeal to all peoples and their governments to establish conditions of lasting and stable peace.

Signers

This statement was unanimously adopted by the following scientists:

Australia. M. L. E. Oliphant and Hans Thirring.

Canada. Brock Chisholm and Sir Robert Watson–Watt.

Czechoslovakia. Viktor Knapp and J. Kozesnik.

Denmark. Mogens Pihl.

France. Father Daniel DuBarle, Bernard Gregory, J. Gueron, and Antoine Lacassagne.

German Democratic Republic. Gunther Rienacker.

Federal Republic of Germany. Max Born, G. Burkhardt, Helmut Honl, Werner Kliefoth, and Hanfried Lenz.

Great Britain. Lord Boyd-Orr, Dame Kathleen Lonsdale, C. F. Powell, M. H. L. Pryce, J. Rotblat, and George Thomson.

Hungary. Lajos Janossy.

India. K. S. Krishnan and P. C. Mahalanobis.

Italy. E. Amaldi and E. Boeri.

Japan. Iwao Ogawa, S. Tomonaga, Yasuo Miyake, Shoichi Sakata.

Netherlands. B. R. A. Nijboer.

Norway. Gunnar Randers.

Poland. Leopold Infeld.

United States. Harrison Brown, David Cavers, William Davidon, Bernard Feld, Bentley Glass, Morton Grodzins, David Hill, H. J. Muller, Jay Orear, Harry Palevsky, Linus Pauling, Vance L. Sailor, Frederick Seitz, Walter Selove, Eugene Rabinowitch, Alvin Weinberg, Victor Weisskopf, and Eugene Wigner.

U.S.S.R. N. N. Bogolubov, N. A. Dobrotin, E. K. Fedorov, E. A. Korotin, A. M. Kuzin, V. P. Pavlichenko, D. V. Skobeltzyn, A. V. Topchiev, V. S. Vavilov, and A. P. Vinogradov.

Yugoslavia. Paul Savic.

Division Changes at National Institutes of Health

The U.S. Public Health Service has announced the creation of the Division of General Medical Sciences and the reorganization of the Division of Research Grants at the National Institutes of Health. The new division will have three main functions: (i) administration of research project grants in the basic sciences and other fields, (ii) support of training in the medical sciences through fellowships to individuals and research training grants to universities and medical colleges, and (iii) administration of the Center for Aging Research. The first two functions have been transferred from the Division of Research Grants; the third from the National Heart Institute.

The Division of Research Grants becomes responsible for the study and evaluation of all research grant and fellowships programs at the National Institutes of Health. It will continue to provide for all institutes and divisions (i) a mechanism for technical review of applications for grants and fellowship awards through 30 consultant panels called study sections, and (ii) business operations for processing and paying of grant and award funds.

G. Halsey Hunt, formerly chief of the Public Health Service's Hospital Division and more recently director of the Center for Aging Research, has been named chief of the Division of General Medical Sciences. Ernest M. Allen will continue to serve as chief of the Division of Research Grants.

Education in the United States

Educational levels in the United States have been rising steadily since World War II, according to a report from the Metropolitan Life Insurance Company. In 1957 more than two-fifths of the population at ages 25 and over had at least a secondary-school education, compared with only one-fourth in 1940. During the same period the proportion of adults with limited schooling declined substantially, those with less than 5 years of formal education dropping from about 14 percent to 9 percent.

As a result of the long-term trend toward increased schooling, the proportion of persons who have gone through high school or beyond is now markedly greater at the young adult ages than at the older ages. For example, two-thirds of the white women now aged 20 to 24 have had that much education. By comparison, the proportion is two-fifths for women at ages 45 to 54 years and only a little more than one-fifth for those past 65.

With the continuing rise in the educational level, by 1975 more than one-half of the adult population will have had at least a high-school education, and almost one-tenth will have received a college degree. Among the white male population, about one-seventh will have completed college. It is predicted that the population of college graduates in the country in 1975 will be at least two-thirds greater than the present total of 8 million.

National Institute for Atmospheric Research

Fourteen universities are represented on a University Committee for Atmospheric Research that is establishing a National Institute for Atmospheric Research with a federally supported, multimillion-dollar, 5-year budget. Twelve of the institutions already have pledged participation in a nonprofit corporation to

Hugh Ferriss' rendition of the Smithsonian Institution's new Museum of History and Technology as seen from Constitution Avenue. Building was designed by the architectural firm of McKim, Mead, and White (see "Imaginary tour," page 1057).

run the institute. The University of Chicago was the first university to make a positive response to the project.

The University Committee for Atmospheric Research was organized in February 1958 as a result of recommendations made in January by the National Academy of Sciences Committee on Meteorology. In mid-July, an agreement was drafted at a meeting at Pennsylvania State University. The announcement that 12 universities have joined the compact was made on 9 October in New York City at the Gold Medal Award dinner of the New York Board of Trade.

Royalties for Atomic Work

A claim for royalties on the gaseous diffusion method for separating uranium-235 from uranium-238 is currently under consideration by the Atomic Energy Commission and is expected to be settled within a few months. The claim was put before the commission's Patent Compensation Board by the Basic Science Foundation, an organization founded by the four scientists, John R. Dunning, Eugene T. Booth, Alfred O. C. Nier, and Aristid V. Grosse, whose work led to the development of the separation process. The claim, if it is granted, is expected to involve large amounts of money, as the award would be based on the value of the uranium-235 produced since the development of the process.

Two other major awards have been made under the patent provisions of the Atomic Energy Act of 1946, one of $300,000 to Enrico Fermi and his associates and one of $400,000 to Glenn Seaborg and three of his colleagues.

Balloon-Borne Laboratory

The Office of Naval Research is currently engaged in a program which is ultimately aimed toward making available to academic, industrial, and governmental scientists a manned balloon-borne laboratory, 20 to 30 miles above the earth, for the purposes of research, environmental testing, and systems experimentation. Three ONR stratospheric flights, made with two-man crews within a sealed gondola and reaching altitudes up to 86,000 feet, have demonstrated the technical and economic feasibility of the "strato-lab" concept.

Prior to initiating the construction of a fully instrumented research vehicle, however, ONR has decided to sponsor a study divided into the following phases: (i) to determine comprehensively what research objectives a manned, stratosphere laboratory 20 to 30 miles aloft might serve, and roughly what the relative significance of those objectives might be; (ii) to state the requirements for the strato-lab stemming from each of the research objectives considered; (iii) to state the specifications for a strato-lab cabin system, optimizing its characteristics to best meet the complex combination of requirements resulting from the functions desired.

A preliminary classification of the possible fields where a strato-platform might be useful is as follows:

1) Physical science—astronomy, astrophysics, geophysics, meteorology, (static, dynamic), physics of the upper atmosphere, geodesy, propagation (ionospheric, tropospheric).

2) Medical, biological, and psychological sciences, including: (i) the effects of the environment on animals, (ii) exploration of the distribution of spores, and so on, in the stratosphere.

3) Testing of military and commercial equipment and techniques; use of environment for test purposes; testing of parachute and escape procedures.

4) As a laboratory tool in systems research: as a laboratory for developing systems which may involve tethered, unmanned balloons, such as a balloon-borne antenna for radar or relay purposes, or military reconnaissance. Here the usefulness of the strato-lab lies not in comprising an element of the proposed system, but rather in its employment as a laboratory for the study and development of such balloon-borne elements.

It is the opinion of ONR that the areas of phase i are so broad and diversified that no single organization can fully explore them; rather, the scientific community as a whole must be asked to assist in planning a program of research for the strato-lab. Accordingly, ONR has asked the Vitro Laboratories, Silver Spring, Md., to put these questions before the scientific community: Would a manned balloon-borne stratospheric laboratory assist or further your research and development activities? How? What functional requirements, that is, stability, weight, etc., would these activities impose on the Strato-Lab?

Correspondence should be addressed to: Vitro Laboratories, Silver Spring Laboratory, 14000 Georgia Ave., Silver Spring, Md.

Business and Education

A study conducted by the Council for Financial Aid to Education has shown that American business in 1956 directed 34 percent of its philanthropic giving to education. A total amount of $28.5 million was donated to educational institutions by the 275 business concerns which were examined in the council's study. The survey showed that the company groups with the highest average gifts to education were electrical machinery, mining, chemicals and petroleum, and coal. The lowest average contributions were made by banking, insurance, utility, and telecommunication groups.

Of the companies in the survey, 20 percent had given more than $100,000 to education. More of the money was in the form of unrestricted gifts than ever before, and there was less endowment giving. The council estimated that in 1956 all business concerns in the nation had contributed $110 million to education.

Russian Medical Literature

A 90-page source book on Russian medical literature has been published by the National Library of Medicine, Public Health Service. Entitled *Guide to Russian Medical Literature*, the book lists 137 important Russian medical journals, reviews 20 Russian journals in the medical and biological fields which are available in complete English translation, and describes sources from which Russian journal literature may be ob-

tained. It also contains a detailed description of available bibliographical sources—in English, Russian, and other languages—on Russian materials in special subject areas.

Translations from articles in Russian and Bulgarian giving information about medical libraries, medical publications, and medical bibliography in the Soviet Union are included. Annotations indicate the Russian bibliographies that are available in the National Library of Medicine.

The book was edited by Scott Adams, librarian of the National Institutes of Health, and Frank B. Rogers, director of the National Library of Medicine. Copies of the publication (Public Health Service Publication No. 602) are available from the Superintendent of Documents, Government Printing Office, Washington, D.C., at 40 cents each.

News Briefs

The Howard E. Tatel radio telescope, the first instrument to be installed at the National Radio Astronomy Observatory that is being constructed at Green Bank, W. Va., by Associated Universities, Inc., was dedicated on 16 October. The new radio telescope is an 85-foot parabolic reflector built by the Blaw-Knox Company of Pittsburgh, Pa. The instrument was named to honor the memory of the late Howard E. Tatel, who at the time of his death in 1957 was chairman of the earth physics section of the Department of Terrestrial Magnetism, Carnegie Institution of Washington.

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The unveiling of the new electronic warfare simulator at the Naval War College, Newport, R.I., originally scheduled for 1 November, has been postponed until 7 November.

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The National Science Foundation has announced completion of its move to new quarters. All offices are now centralized in one building located at 1951 Constitution Ave., NW, Washington 25, D.C.

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British scientists have produced what is believed to be the first effective vaccine against worm disease, one of the greatest cattle breeding problems throughout the world. The vaccine is the result of work carried out over the past few years by W. Mulligan and a number of his colleagues in the Veterinary School at Glasgow University. The new vaccine is based on the treatment of lung worm larvae with x-rays. The larvae are not killed by this irradiation, but they are so altered that when given to a calf they do not live long enough to produce true disease. They do, however, stimulate the antibody-producing machinery of the calf so that it shows increased resistance to infection by lung worm larvae when it comes across them on pasture.

* * *

The Hunter Radiation Therapy Center for research and treatment has been opened at the Yale–New Haven Medical Center. The facility, which cost more than $1,200,000, is equipped with a 2 million electron-volt Van de Graaff deep-therapy radiation machine, in addition to three other radiation devices for treating many kinds of tumors and related diseases. The center is housed in a four-story building which has a special concrete sub-structure to shield the Van de Graaff generator.

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Dartmouth College will become the base for two major Army Engineer polar research agencies. The move may lead to the establishment of the college as the western world's chief center for polar studies. The agencies involved are the Snow, Ice, and Permafrost Research Establishent and the Arctic Construction and Frost Effects Laboratory. A meeting at Hanover, N.H., in December will decide whether a polar research center should be established at the college under the auspices of the National Academy of Sciences.

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An Institute of Space Sciences has been established at the University of Cincinnati to provide advanced training and research in the new field of astrodynamics. Paul Herget will be the director. He is director of the Cincinnati Observatory and scientist in charge of the Vanguard computing center, Washington, D.C. Beginning in September 1959, the institute proposes to give a 3-year curriculum leading first to a master of science and then to the doctor of philosophy degree in dynamical astronomy. In the past 14 years, only two doctorates in this field have been awarded in the United States.

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The Navy has announced selection of the Stratobowl, near Rapid City, S.D., as the launching site for a manned, high-altitude balloon flight in early November to study Mars. John Strong, director of the Laboratory of Astrophysics and Physical Meteorology, Johns Hopkins University, under contract with the Office of Naval Research, will make the ascent to determine the water vapor content in the Martian atmosphere. Cdr. Malcolm D. Ross, USNR, Navy balloonist and Office of Naval Research physicist, will pilot the balloon.

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Columbia University's Oceanographic research vessel *Vema* has embarked on a 10-month cruise that will take the ship from New York, through the Panama Canal, down the west coast of South America, through the Straits of Magellan, across the South Atlantic to the western coast of Africa, and back to New York via the Caribbean area late next August. This fifteenth cruise by the *Vema* is expected to provide a major contribution to the knowledge of the biology, geology, and oceanography of the South American area and of the South Atlantic Ocean.

Scientists in the News

SVERRE PETTERSSEN, professor of meteorology at the University of Chicago and director of the university's Weather Forecasting Research Center, has received the New York Board of Trade's annual Gold Award. He is the first scientist named to the honor in the 12 years the award has been given. Previous winners have included President Eisenhower, former President Herbert Hoover, and Winston Churchill.

Surgeon General Leroy E. Burney has announced the appointment of H. VAN ZILE HYDE as assistant to the surgeon general for international health. Hyde, chief of the Public Health Service's Division of International Health for 5 years, is succeeded in that post by HORACE DELIEN, who has directed the health program of the International Cooperation Administration in the Philippines for the past 7 years.

The Helen Hay Whitney Foundation has announced that LUIS F. LELOIR, director of the Instituto de Investigaciones Bioquimicas, Fundacion Campomar, Buenos Aires, Argentina, has been selected as the first recipient of the T. Duckett Jones Memorial Award. This $6500 award, which will be an annual presentation, is being given to Leloir in recognition of his work on the isolation of uridine by diphosphoglucose from plant and animal tissues. On 11 October, during the first Helen Hay Whitney Foundation Connective Tissue Conference, a reception and dinner were held at the Princeton Inn, Princeton, N.J., to honor Leloir.

The following mathematicians have reported new appointments for the academic year 1958–59.

R. C. BUCK, professor at the University of Wisconsin, has received a Guggenheim fellowship and will be at Stanford University.

H. G. COHEN, professor at Rensselaer Polytechnic Institute, will be a senior research scholar under the Fulbright program at the Technische Hogeschool, Delft, Netherlands.

JOHN DYER-BENNET, associate professor at Stanford University, has been awarded a National Science Foun-

dation science faculty fellowship and will be in Zurich, Switzerland.

N. J. FINE, professor at the University of Pennsylvania, will be on sabbatical leave as a John Simon Guggenheim memorial fellow at the Institute for Advanced Study.

D. T. FINKBEINER, professor at Kenyon College, has received a National Science Foundation fellowship and will be at Princeton University.

LEONARD GILMAN, professor at Purdue University, has received a Guggenheim fellowship and will be on sabbatical leave at the Institute for Advanced Study.

V. L. KLEE, JR., professor at the University of Washington, has received a National Science Foundation senior postdoctoral fellowship and will be at the University of Copenhagen, Denmark.

MORRIS KLINE, professor at New York University, will be on sabbatical leave at the Mathematisches Institut, Technische Hochschule, Aachen, Germany, as a Fulbright lecturer and Guggenheim fellow.

L. C. YOUNG, professor at the University of Wisconsin who is on research leave in Europe, has received a George Ives Haight traveling fellowship.

OSCAR ZARISKI, professor at Harvard University, has been elected to a corresponding membership by the Academia Brasileira de Ciencias, Rio de Janeiro, Brazil.

Major General DAN C. OGLE, Surgeon General of the Air Force for the past 4 years, will retire on 30 November after almost 30 years active service. A chief flight surgeon since 1932, Ogle has devoted himself to aeromedicine in its broadest aspects.

Major General OLIVER K. NIESS has been appointed Surgeon General of the Air Force, effective 1 December. At present he is serving as command surgeon of the Pacific Air Forces in Hawaii.

JOHN W. ABRAMS of the Canadian Defense Research Board and scientific adviser to the chief of the Air Staff, Royal Canadian Air Forces, has accepted a temporary assignment with Supreme Headquarters Allied Powers Europe (SHAPE) to assist in the scientific analysis and planning of Western European air defenses.

EMIL G. KLARMANN, vice president in charge of technical services for Lehn and Fink, Inc., has been named recipient of the Achievement Award of the Chemical Specialties Manufacturers Association. He will be presented the award in New York on 10 December. Klarmann is being honored for his work in the fields of disinfection and sanitation. He has been instrumental in the development of the nontoxic formula for Lysol brand disinfectant; of the professional disinfectants, Amphyl and O-syl; and of Lehn and Fink instrument germicide for surgical purposes.

K. AA. STRAND, research associate (professorial rank) with the University of Chicago, has been appointed director of the Astrometry and Astrophysics Division of the U.S. Naval Observatory, Washington, D.C. He will continue his connection with the university.

DAVID D. KECK, assistant director and head curator of the New York Botanical Garden, is taking a year's leave of absence to serve as program director for systematic biology at the National Science Foundation.

EDWARD B. ESPENSHADE, JR., chairman of the department of geography at Northwestern University, has been named chairman-designate of the earth sciences division of the National Academy of Sciences–National Research Council. He will become chairman of the division on 1 July 1960. The 6-year appointment concludes with a 2-year term, beginning in 1962, as past chairman.

MARVIN L. GRANSTROM, formerly an associate professor at the University of North Carolina, has been named chairman of the department of civil engineering in Rutgers University's College of Engineering. He succeeds W. BREWSTER SNOW, professor of civil engineering, who has relinquished administrative duties in order to devote more time to research and teaching.

Recent Deaths

EDWIN BETTS, Charlottesville, Va.; 65; professor of biology at the University of Virginia and an authority on the gardening and farming practices of Thomas Jefferson; 27 Sept.

ANDREW A. BORLAND, University Park, Pa.; 80; head of the department of dairy science at the Pennsylvania State University from 1919 until his retirement in 1948; head of animal and dairy husbandry at the University of Vermont from 1911 to 1915; 13 Oct.

WARREN S. BOURN, Munden, Va.; 62; retired biologist of the U.S. Fish and Wildlife Service, Division of Wildlife Refuges; internationally known as a specialist on marsh ecology; 24 Aug.

P. F. ENGLISH, State College, Pa.; 64; professor of wildlife management at Pennsylvania State University since 1938; head of the department of zoology and entomology from 1951 to 1953; president of the Wildlife Society since 1946; 8 Oct.

ESTHER M. HILTON, New York, N.Y.; 59; since 1953 professor of social work in the Graduate School of Public Administration and Social Service of New York University; former supervisor of special public assistance projects of the department of social welfare of New York State; 10 Oct.

VICTOR L. KING, Bound Brook, N.J.; 72; chemical engineer; retired in 1957 as technical director for the Calco Chemical Division of the American Cyanamid Company; vice president of Rhodia, Inc., New Brunswick, N.J., since 1957; had worked with August Heckscher, Thomas Edison, and August Belmont; 12 Oct.

Rev. PIERRE LEJAY, Paris, France; 60; geophysicist and president of the French Committee for the International Geophysical Year; president of the International Scientific Radio Union; vice president of the International Council of Scientific Unions, and former director of the Zi-Ka-Wei Observatory in Shanghai; reported in 1939 that the American continent was slowly moving westward, while Asia was fluctuating between east and west; published many papers on geophysics, gravimetry, astronomy, and the ionosphere; 11 Oct.

DANIEL J. McCARTHY, Ventnor, N.J.; 84; neurologist and former professor of medical jurisprudence at the University of Pennsylvania; former director of the medical department of the Municipal Court; 9 Oct.

MILES S. MURPHY, Philadelphia, Pa.; 57; specialist in psychological and educational guidance; had taught at the University of Pennsylvania for 35 years; named professor of psychology in 1950; 3 Oct.

NELSON M. PERCY, Chicago, Ill.; 82; chief of staff at Augustana Hospital from 1935 until his retirement in 1957; professor emeritus of clinical surgery of the University of Illinois Medical School; developed the Percy method of donor-to-patient whole blood transfusion; developed the mass plasma technique; coauthor of *Clinical Surgery;* 10 Oct.

HENRY S. THOMAS, Philadelphia, Pa.; 53; director of medical service of the Merck Sharp and Dohme Research Laboratories division of Merck and Company; former medical director of Ciba Pharmaceutical Products, and Nepera Chemical Company; 10 Oct.

KENNETH P. WILLIAMS, Bloomington, Ind.; 71; professor of mathematics at Indiana University until his retirement last June; chairman of the mathematics department until 1944; authority on the Civil War and author of *Lincoln Finds a General;* 25 Sept.

Erratum: In the article "Pavlov and Lamarck," by G. Razran [*Science* **128**, 758 (3 Oct. 1958)], the quotation given in the first sentence of the section "Oral comments" (p. 760) should have read: "Pavlov remarked to me that one of the biggest scientific errors of his life was his assertion that acquired habits could be inherited," instead of ". . . could not be inherited."

Book Reviews

From Ape to Angel. An informal history of social anthropology. H. R. Hays. Knopf, New York, 1958. xxxvii + 440 pp. $7.50.

At the end of the 15th century, when the men of Europe finally broke the powerful bonds of ethnocentric ignorance in which nature and the alien cultures of hostile nations had long held them, their navigators and explorers brought back the first new knowledge about the diversity of life, the complexity of nature, and, for them, an expanding universe. The traditional patterns for identifying and placing the objects of the natural world and themselves and for explaining human experience began to undergo change. Later, when migration and travel spread Western culture across the world, further knowledge and experience resulted in the creation of whole new sciences and secular explanations, such as evolution, to categorize and explain man and his place in nature. Among these new sciences, and rather late in arriving, was social anthropology—the comparative study of men in social groups.

The present volume tells of the development of this science from its early beginnings, when the frontier ethnographers, missionaries, administrators, and others wrote their accounts of the strange cultures of the peoples of Australia, Africa, and the Western Hemisphere; it describes the classical evolutionists' attempts to substantiate simpler unilinear evolutionary theories as substitutes for the sacred account of Genesis. Although Hays, by trade a novelist, centers his account around the persons of the great figures who contributed to the new science of man, he tells his story in such a way that the lay reader is usually informed about the major contributions of each. In part 1 we read about Lewis H. Morgan and his passionate interest in the Indians of upper New York State, of the extension of this interest to the primitive peoples of the world, and of the later development of his evolutionary theories. Here the reader learns about E. B. Tylor, the Englishman who, for many, is the founder of anthropology; about the Scotsman Robertson Smith, whose scientific interest in the traditional Christian doctrine of the sacrifice got him into trouble; and about Sir James Frazier, whose interest in such problems in other cultures got him a knighthood.

In part 2, "The critical reaction," later developments are traced: Westermarck and his evolutionary theory of human marriage (from brutish promiscuity to Victorian monogamy); Van Gennep's *rites de passage*; and Freud's, and others', notions about totemism—the "worship" of species, both plant and animal.

The various theories about the diffusions of culture—among them those of Father Schmidt, Clark Wissler, Robert H. Lowie, and Franz Boas and his followers—are described. This section is followed by chapters on Emile Durkheim, A. R. Radcliffe-Brown, and others intent on developing laws about the nature of human groups. The last part of the book is devoted to contemporary anthropologists and to the use of anthropology in the study of our own people and its implications for present problems.

The book is well written, and at times the story is amusingly told. The anthropologists will find a number of small errors, but most will enjoy reading again about the great and the near great of the past. Others will acquire knowledge about the people who created the science of anthropology and will enjoy the thumbnail sketches of some of the institutions, religions, and cultures of the world. There are short bibliographies (one for each of the 38 chapters), an extensive index, and 32 pages of illustrations.

W. Lloyd Warner
Department of Anthropology, University of Chicago

Introduction to Fourier Analysis and Generalised Functions. M. J. Lighthill. Cambridge University Press, New York, 1958. viii + 79 pp. Illus. $3.50.

Although delta-function techniques had been widely used in physics for 25 years, a unified underlying mathematical justification for *all* of these methods was lacking until Laurent Schwartz developed his theory of distributions. However useful this theory may have been, it had little chance of filtering down to the applied mathematician or theoretical physicist, since it was phrased in the language of abstract spaces. M. J. Lighthill has, in the present book, presented an extremely lucid and well-written account of a simplified version of the theory, attributable to George Temple. By choosing a sufficiently restricted class of functions, Lighthill shows that many of the "illegal" tricks that use delta functions and Fourier transforms which do not exist in the ordinary sense have, in fact, a prosaic legality.

After discussing the basic notions of one-dimensional generalized functions, Lighthill goes on to the application of distribution theory to the asymptotic evaluation of Fourier transforms and the coefficients of Fourier series. In passing, Lighthill is able to show that Hadamard's theory of the finite part of an infinite integral is an almost trivial result of the present theory. The only defect of the book is one of omission—there is no discussion of generalized functions in higher dimensions. Apart from that, I find the book to be a stimulating and valuable addition to the literature of applied mathematics, with a good deal of the charm of 18th-century mathematics. It may well become a minor classic before very long.

George Weiss
Institute for Fluid Dynamics and Applied Mathematics, University of Maryland

Concepts of Classical Optics. John Strong. Freeman, San Francisco, 1958. xvi + 692 pp. Illus. $9.50.

Written as a textbook for an intermediate course in optics, this volume, with its lively and original treatment of the subject, will also be useful for reference purposes. In the first 12 chapters the author covers physical optics, intentionally omitting spectra and most of crystal optics; the following four chapters are devoted to geometrical optics. The reason for reversing the usual order is not apparent, since no attempt is made to discuss the diffraction theory of aberrations. The latter part of the book—almost half—is devoted to 17 appendices consisting of essays written by outstanding authorities on topics of current research interest. Several of these are valuable summaries of material that cannot be conveniently found elsewhere. Outstanding in this respect are the articles by Jacquinot on apodization, by Greenler on optical filters, by Yates on radiation detectors and measuring devices (including the eye), and by Kapany on fiber optics.

The author, professor of physics at Johns Hopkins University, is well known for having carried on that university's

tradition of ingenious experimentation in optics—a tradition associated with the names of Henry Rowland and R. W. Wood. His flair for practical laboratory procedures shows itself throughout the book in useful descriptions of ways of testing lenses, selecting and polishing optical materials, and the like. That he is also very conscious of the "honorableness and antiquity" of his subject is evidenced by frequent historical references and direct quotations from original sources. The continuing growth of the field, on the other hand, is emphasized by several descriptions of recent developments.

One has the impression that the author continually strives to break away from the traditional presentation. In some respects this originality may not make for easy comprehension by the student. The suggested problems will challenge even the brightest. The notation, for which not only Greek but also German script symbols are used, gives a somewhat confusing impression, especially when the latter are adorned with combinations of bars and tildes.

Roger Hayward's distinctive drawings are especially helpful where three-dimensional visualization is required. The West Coast publishers are to be congratulated on the attractive appearance of their first volume in the field of physics.

F. A. JENKINS
Department of Physics,
University of California, Berkeley

Scientific Societies in the United States. Ralph S. Bates. Technology Press, Massachusetts Institute of Technology; Columbia University Press, New York, ed. 2, 1958. xiii + 297 pp. $6.50.

This is the second edition of a book with the same title published in 1945 by John Wiley & Sons (and also Chapman and Hall, Ltd., London) for the Technology Press of Massachusetts Institute of Technology. The first five chapters have apparently been reprinted by offset, and hence remain unchanged. The new sixth chapter, "The atomic age, 1945–1955," was added to bring the story up to date.

The scope is indicated by the chapter titles: "Scientific societies in eighteenth-century America"; "National growth, 1800–1865"; "The triumph of specialization, 1866–1918"; "American scientific societies and world science, 1919–1944"; and "The increase and diffusion of knowledge."

This is not intended as a handbook of the scientific societies, such as *Scientific and Technical Societies of the United States and Canada* (National Academy of Sciences–National Research Council, Washington, ed. 6, 1955), which provides detailed information on 1712 societies. Instead, this book is a historical account of American scientific organizations from the colonial period to the present. (The author is professor of history at Massachusetts State Teachers College, Bridgewater.) Thus individuals, scientific developments, trends, societies, and governmental organizations are interwoven, and the intent has been to emphasize their interacting influences.

It is obvious that much reading and note-taking have gone into the preparation of the book. In the earlier chapters, in particular, many references have been condensed into an interesting history. The 432 footnotes and the bibliography will be useful for those interested in the beginnings of science in this country and those stimulated to delve more deeply into the subject.

Throughout the book there are repeated references, and considerable space is allotted, to the American Association for the Advancement of Science, the National Academy of Sciences–National Research Council, the American Academy of Arts and Sciences, the American Philosophical Society, and the Smithsonian Institution. This is not excessive in view of their long histories and ramified activities. On the other hand, the objectives and work of the Federation of American Societies for Experimental Biology, the American Institute of Physics, the American Geological Institute, and the American Institute of Biological Sciences all merit more attention. About five pages are devoted to UNESCO. The National Science Foundation, with no explanation of what it is or how it came into existence, is mentioned only twice and then in connection with other agencies.

A great many scientific societies are included but, inevitably, not all. Nearly all of the larger national scientific and engineering societies are present but, in many instances, coverage in the text is limited to a bare listing of names and the dates of founding. Sometimes national societies are rather uncritically grouped with less technical or local organizations. Since some degree of selection and compression were necessary, many of the points made might have had a few societies as examples instead of a dozen or more run together. The others, perhaps, could have been added in footnotes. Occasional paragraphs packed with long lists of societies, all founded about the same time or more or less in the same field, impart a checklist or compendium-like flavor and make the book less readable.

Since most of the state and city academies of science are included, probably all should have been. Among the regional societies, one finds the Western Society of Engineers but not the Western Society of Naturalists. The Southwestern Association of Naturalists is noted on both pages 197 and 198, but the older and larger Association of Southeastern Biologists has been overlooked. In surveying so many organizations over so many decades an occasional slip has occurred. To cite two: the American Association for the Advancement of Science was incorporated in 1874, not by Congress, but under the laws of Massachusetts; and it is the American Institute *of* Chemical Engineers, not *for*. But, in general, with such a plethora of names and dates, it is remarkable how relatively free from errors, typographical or otherwise, the book is.

The over-all impression is not unfavorable. The book is informative and provides, in the earlier chapters especially, a good introduction to a very complex and difficult subject.

RAYMOND L. TAYLOR
AAAS

The Reach of Science. Henryk Mehlberg. University of Toronto Press, Toronto, Canada, 1958. ix + 356 pp. $5.50.

As the title of this book indicates, the author is concerned with the range of applicability of scientific method to the problems of men. His conclusion is that "the universality of scientific method establishes that whatever is knowable is scientifically knowable" (page 343). His analysis leading to this conclusion is divided into three parts, which constitute the main divisions of the book. Part 1 deals with the concept of scientific method; part 2 considers the method of science; part 3 discusses the universality of science.

Throughout his analysis the author gives the principle of verifiability a central role, although, in the light of the recent literature on the difficulties of making this principle a criterion of meaningfulness, he attempts to connect verifiability to the truth rather than the meaning of statements. His discussion in various places of the relation between ostensive terms, conditional definitions, and the verifiable status of quantitative concepts is particularly good.

The author states in the preface that in spite of his concern with a single issue —the scope of science—he has in the course of his analysis dealt with the main problems of scientific methodology. It is in this connection that I have certain reservations about the book. On the one hand, I find myself agreeing with most of what the author has to say. His gen-

eral position seems sound and exceedingly sensible. On the other hand, what he has to say about probability, induction, or the theory of measurement would not give an uninitiated reader any feeling for the fact that these areas of the philosophy of science are full of exact results and specific unsolved problems. There is also, it seems to me, a disproportionately detailed discussion throughout the book of the relevance for scientific method of recent results in mathematical logic in comparison with the discussion of corresponding results in mathematical statistics.

PATRICK SUPPES
Applied Mathematics and Statistics Laboratory, Stanford University

Principles of Field Biology and Ecology. Allen H. Benton and William E. Werner, Jr. McGraw-Hill, New York, 1958. vii + 341 pp. Illus. $6.50.

By approaching ecology from three directions—as a field study, as a taxonomic challenge, and as an economic problem because of man's biasing effects—Benton and Werner demonstrate a close relationship between the various principles described. A surprising amount of space is given to a clear account of the development of field biology in America, a topic usually neglected in any volume dealing with population dynamics and ethology. The concluding chapters, on the use of biological literature and on the choice and conduct of a field problem, will be helpful to advanced undergraduates and beginning graduate students.

The references following each chapter and a glossary of terms used in the book offer assistance and make the text matter itself more lively and interesting.

LORUS J. MILNE
MARGERY MILNE
Department of Zoology, University of New Hampshire

Morphology of Plants. Harold C. Bold. Harper, New York, 1957. xxiii + 669 pp. Illus. $8.

This textbook organizes in one volume a survey of the whole plant kingdom. To cover this great diversity the author has adopted the "type method"—that is, the use, for each major group, of illustrative types for detailed study. Wherever possible the types are genera that are readily obtainable. Bold admits that there will be inevitable disagreement about emphasis and choice of types, but on the whole he seems to have made an excellent selection.

In format the volume is neat and attractive. In general, each major group of plants is dealt with in one chapter, which comprises an introduction or description of the general features of the groups, followed by detailed coverage of representatives. Coordination of the diverse subjects is accomplished largely by recapitulations and summaries. The greater part of the book concerns living plants. The treatment of fossil plants is concentrated in a single chapter, "Plants of the past," which is presented after all the living forms have been discussed. Although this approach has the disadvantage of separating the fossils from their nearest living relatives, it has the advantage of serving as a review and synthesis of the plant groups. It can also serve mechanically to bring all the fossil forms together in the laboratory.

The author has relied more heavily than the writers of conventional texts on photographic illustrations. Many of those that are included are good, but unfortunately many are only fair—either not clear or out of focus. More labeling might improve some of the photographs and drawings and increase their effectiveness.

A very useful appendix (pages 621–652) describes procedures and devices for preparing laboratory materials and adds much to the value of the book. It is Bold's belief that living materials are indispensable for good teaching. I believe that many teachers have a need for instruction, however, if this high ideal is to be achieved. The author has met this need by providing numerous tips on techniques, many of them original. Another pedagogically desirable innovation, in my opinion, is the providing of derivations of scientific names from the Greek or Latin roots.

My major criticism is that the number of plant divisions (the phyla) has been increased to approximately double that taught by most teachers. Bold has made a radical (called "conservative") classification that treats vascular plants, for example, in nine separate divisions —Psilophyta, Microphyllophyta, Arthrophyta, Pterophyta, Cycadophyta, Ginkgophyta, Coniferophyta, Gnetophyta, and Anthophyta. He holds that evidence of ultimate interrelationships of these assemblages, especially among land plants, is so tenuous that they must be considered as polyphyletic.

One may argue that not enough attention has been given here to efforts of phylogenists and taxonomists to detect and correlate not only differences but resemblances as well, and to weigh them justly. I really wonder whether the beginner in morphology has the necessary equipment to evaluate, on so little evidence, the propriety of the various "phylogenetic speculations," or whether an elementary textbook such as this one is the appropriate arena for such discussion.

The author, obviously, has not tried to avoid controversy in his presentation. This is evident again, for example, in his dealings with the interesting idea that seed plants are homosporous. There is no question in my mind that the text will stimulate both the teacher and the student. The style of writing is good, the book is interesting, and the text, in general, seems to me to be superior. Teachers will undoubtedly find the book a most valuable text, and it is probable that biologists in other fields will find it a useful and handy reference to general plant morphology.

WARREN H. WAGNER, JR.
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De l'actinie à l'homme. vol. 1, *Anticipation et mémoire.* Bases de l'évolution psychique. Henri Pieron. Presses Universitaires de France, Paris, 1958. viii + 306 pp. F. 1600.

Henri Pieron (1881—), who began his psychological writing just after the turn of the century, has been the leader in experimental psychology in France for the past 40 years. He inherited Binet's laboratory at the Sorbonne and Ribot's chair in the College of France and has been editor of *l'Année* since the 1920's. These important positions have enabled him to experiment, to lecture, and to publish extensively. This latest book, *De l'actinie à l'homme,* volume I, is a collection of 33 of his articles taken from 17 different journals, all French except one—a 1938 Russian journal of physiology. The dates of the articles range from 1907 to 1946, only four having appeared after 1916.

The collection is arranged in four parts: the first pertains to methodological problems of an objective psychology; the second, to studies of rhythms of behavior in sea anemones, certain Crustacea, and man; the third, to studies of mnemonics or cues for homing and direction orientation in mollusks and ants; and the fourth, to studies of memory in mollusks and to some general observations on animal memory. Each part begins with a brief introduction that has as its goal the tying together of the different parts in such manner as to show that anticipation (revealed by rhythms of behavior) and memory are the evolutional bases of mind. I am not enthusiastic about this aspect of the volume, for while the book thus provides in one place many facts about animal behavior, it does not make clear which of the connections that Pieron sees are his own

inferences and which pertain to characteristics of the animals involved.

Neither is it clear for whom the book is specifically designed. The American graduate student in physiological psychology might find it useful. It could serve to acquaint him with the work of France's greatest psychologist in the physiological tradition—an acquaintance that is seldom made. In the psychological literature that is widely regarded as basic in graduate training, one finds slight reference to Pieron. Thus, this selection of writings from one of the world's most prolific psychologists could have an effect in an unanticipated direction.

JOHN B. WOLFE
Department of Psychology,
University of Mississippi

A History of Public Health. George Rosen. MD Publications, New York, 1958. 551 pp. $5.75.

This book is a "comprehensive international account of community health action." History's importance is indicated by the statement, "Every situation that man has faced and every problem that he has had to solve have been the product of historical developments." A paragraph from the volume's jacket defines public health. "From the earliest civilizations to the present, communities have endeavored to cope with health problems that arise as a result of human beings living in groups. Such problems include the control of infectious diseases, the provision of water and food, maintaining a sanitary environment, supplying medical care and providing for the disabled and destitute. When a group is involved, these problems cannot be handled individually, they require action by the community, and as a result there has developed what we know as *public health.*"

Rosen quotes the late Herman Biggs as follows: "Disease is largely a removable evil, it continues to afflict humanity, not only because of incomplete knowledge of its causes and lack of individual and public hygiene, but also because it is extensively fostered by harsh economic and industrial conditions and by wretched housing in congested communities. These conditions, and consequently the diseases that spring from them, can be removed by better social organization. No duty of society, acting through its governmental agencies, is paramount to this obligation to attack the removable causes of disease . . ." The author himself says: "These developments must be seen, however, not alone as events peculiar to the United States but in perspective of a world wide historical evolution that has brought into being the modern state with its concern for individual, family and community needs for organized social security and service. . . . Today, the principle of state intervention and control in health matters is admitted. . . . Its emergence has resulted from the interaction of important economic and social trends." It is the business of a history of public health to tell the story of this development, and since many nations have contributed, of necessity that narrative must be international.

George Rosen writes from a rich personal background and from a broad point of view, drawing on the experiences of Classical Greece, Imperial Rome, the Medieval World, Italy, Spain, France, Germany, England, and the United States, chiefly, with references to China, India, the Near East, Eastern Europe, and such other parts of the world as contribute to the complete picture.

Following the customary foreword, preface, and acknowledgments, the subject is discussed in seven divisions: "The Origins of Public Health"; "Health and the Community in the Greco-Roman World"; "Public Health in the Middle Ages"; "Mercantilism, Absolutism and the Health of the People"; "Health in a Period of Enlightenment and Revolution"; "Industrialism and the Sanitary Movement"; and "The Bacteriological Era and its Aftermath" (in two sections). Public health is treated from its earliest history to 1950. There are nearly 140 headings of the subject matter under these seven divisions, among them: "Airs, waters and places"; "Baths as well as bread and circuses"; "Leprosy—the great blight"; "Toward a national health policy"; "The bookkeeping of life and death"; "Lunacy and conscience"; "Enter Mr. Chadwick"; "First steps toward international health organization"; "The vanishing diseases"; "The rise of scientific nutrition"; "The responsibility of government for the advancement of health"; and "The health and welfare of the industrial worker."

When it is recalled that the book is limited to 551 pages, the author may be forgiven if some aspects of public health history are not covered to the satisfaction of the reader. The discussion on vaccines should have mentioned smallpox vaccine again, should have included the work of F. F. Russell on typhoid vaccine, and should have included whooping cough (pertussis) vaccine; moreover, Rosen tells only part of the story when he makes no mention of the toxoids—diphtheria and, particularly, tetanus. Within the space available, industrial problems are well covered, but one feels a lack of coverage of the accomplishments of military medicine in public health and of the geography of disease. Perhaps more could be said about the Crusades, and about the discovery of new lands and the movements of peoples. Nevertheless, the book is a remarkably complete collection of data, and the story is admirably told.

The author makes few references to the future. Past may be prologue, and no doubt we can better understand the present and cope with the future because of our knowledge of history, but it would be unwise to attempt to reveal the future—a fact no one knows better than the historian. Too many factors impinge on the firm base of the past for us to be sure just what the future will be, although certain general trends may be clear.

The book contains no charts, diagrams, maps, plates, or illustrations but does include eight simple tables. I have two comments to make regarding them. Table III was not intended by the author to do more than illustrate his statement: "Then with the 1880's the golden age of bacteriological discovery was ushered in . . . causative organisms of various diseases were demonstrated in rapid succession, often several in one year. The explosive character of this process is clearly seen from Table III." This table is headed "Discovery of pathogenic organisms," and the title is misleading. A better one would be "Early discoveries of pathogenic organisms," or "Discovery of some important pathogenic organisms." The table also contains minor errors. Thus, the pneumococcus, the discovery of which is attributed to Fraenkel, 1886, was described by Pasteur as a septicemic microbe of saliva in 1881 and, in the same year, by Sternberg as a micrococcus of rabbit septicemia. The organism of leprosy, not even yet cultivated in the laboratory, was seen and described by Hansen in 1874, significantly earlier than the date 1880 given in the table. Soft chancre should be dated 1889 instead of 1887. I do not see why the anthrax bacillus (1876, Koch) was not included, since it was in a way the fuse that touched off the era, and for that matter the gonococcus, the meningococcus, and the organisms that cause whooping cough, tularemia, relapsing fever, and syphilis might well have been included because of their importance. Since the table includes the animal parasite that causes malaria and is not therefore restricted to bacteria, it would be logical to include also representative virus and rickettsial diseases, such as rabies, smallpox, typhus, and yellow fever, although to do so could be confusing, since the emphasis is on the last two decades of the 19th century as the golden era of bacteriological discovery.

My criticism here arises from the fact that a book as interesting, comprehensive, and authoritative as this one will be read by many people, some of whom

will not have sufficient background to realize that the organisms listed are only a few of those that cause disease and that it is not always easy to state when a certain discovery was made.

Another minor criticism is that the names in the tables are not indexed, nor are they uniformly presented. Thus, the complete names of 11 persons named in Table VII are given, whereas for the more than 30 persons listed in Tables III and IV, with one exception, only the last names are given. The historical accuracy of the author is attested to by that one exception. In Table III, Fraenkel is listed with his initial, A., presumably so that he will not be confused with Karl Fraenkel, mentioned a few pages further on by his full name.

The text is followed by a bibliography of some 200 titles, mostly in English—intentionally a simplified list, designed to facilitate further reading by those interested.

Next in order is a section entitled "Memorable figures in the history of public health," which, in 9 pages, presents thumbnail sketches of 68 "figures," from Empedocles of Agrigentum to Charles-Edward Amory Winslow. One wonders what led the author to choose the four women and the 64 men he has named, but the choice certainly serves a very useful purpose in that it challenges the reader to produce a better list. Some, certainly, of the following could, in my judgment, have been included: Hans Zinsser, Milton J. Rosenau, Charles V. Chapin, William T. Sedgwick, Frederick Fuller Russell, James S. Simmons, Edward L. Trudeau, William C. Gorgas, Athanasius Kircher, and William Pickles, the English country doctor. I have no quarrel with the selection Rosen has made, which is that of outstanding figures throughout the centuries covered.

A "Selected list of periodicals concerned chiefly or entirely with public health" occupies pages 516 to 519 and includes more than 80 publications from 33 countries. Next come 3½ pages naming 75 public health societies and associations in the United States and other countries. On pages 524 and 525, schools of public health in 16 foreign countries and the 11 schools of the United States are listed.

Indexes are important for a book like Rosen's *A History of Public Health*. In this respect the book is excellent. There is a subject index of 18 double-column pages, comprising well over a thousand topics discussed in the text. The author index follows (pages 544 to 551) and includes more than 660 names which have been mentioned. A peculiarity of this index is the fact that, if the name in the text is the last name only (as for instance Wyman), that is all that appears in the index, whereas if the name has appeared in the text in full, it so appears in the index (thus, Edgar Sydenstricker). I think the index would be more useful if all names in the index were given in full. For instance, the following names are not uncommon and should be amplified by inclusion of the Christian name or at least of initials: Ashby, Carpenter, Fuller, Johnson, Kahn, Kirby, and Woods.

This inexpensive and highly readable book can be recommended to all medical students and should be required reading for all students and practitioners of public health. In this era, when great numbers of our lay people read good literature, including scientific books, Rosen's *History* should be an item for their attention. The Janson type used is pleasing to look at and easy to read. Two errors in spelling were found on one page but none elsewhere in the book. I believe this history will appeal to the philosopher as well as to the technologist and will, without doubt, take its place among the outstanding science histories of the times.

LELAND W. PARR
Bacteriology, Hygiene and Preventive Medicine, George Washington University

New Books

Adolescence and the Conflict of Generations. An introduction to some of the psychoanalytic contributions to the understanding of adolescence. Gerald H. J. Pearson. Norton, New York, 1958. 186 pp. $3.95.

Animal Ecology To-Day. vol. VI of *Monographiae Biologicae.* F. S. Bodenheimer. W. Junk, The Hague, Netherlands, 1958. 276 pp.

Annual Reports on the Progress of Chemistry for 1957. R. S. Cahn, Ed. Chemical Society, London, 1958. 465 pp. £2.

The Biology of Hair Growth. William Montagna and Richard A. Ellis. Academic Press, New York, 1958. 537 pp. $15.

Body-Marking in Southwestern Asia. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard Univ., vol. XLV, No. 1. Henry Field. Peabody Museum, Cambridge, Mass., 1958. 175 pp.

Cold Injury, Ground Type. Tom F. Whayne and Michael E. DeBakey. Historical Unit, U.S. Army Medical Service, Dept. of the Army, Washington 25, 1958 (order from Supt. of Documents, GPO, Washington 25). 591 pp. $6.25.

Contributions to the Theory of Nonlinear Oscillations. vol. IV. S. Lefschetz, Ed. Princeton Univ. Press, Princeton, N.J., 1958. 216 pp. $3.75.

Doctor Squibb. The life and times of a rugged idealist. Lawrence G. Blochman. Simon and Schuster, New York, 1958. 383 pp. $5.

Electronic Digital Computers. Their use in science and engineering. Franz L. Alt. Academic Press, New York, 1958. 366 pp. $10.

Flavor Research and Food Acceptance. A survey of the scope of flavor and associated research, compiled from papers presented in a series of symposia given in 1956–1957, sponsored by Arthur D. Little, Inc. Reinhold, New York; Chapman & Hall, London, 1958. 397 pp. $10.

Fourth National Symposium on Vacuum Technology, Transactions, 1957. 9–11 October, Somerset Hotel, Boston, Mass. Wilfrid G. Matheson, Ed. Pergamon, New York and London, 1958. 176 pp. $12.50.

Glass Engineering Handbook. E. B. Shand. Special sections by C. H. Greene and J. A. Grant. McGraw-Hill, New York, ed. 2, 1958. 494 pp. $10.

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Reports

Cultures of Gonads of Mammalian Embryos

Since the explanation of sex reversal in the freemartin was given by Lillie (*1*), there have been a number of attempts to investigate sex reversal experimentally, but, until recently, results with mammalian forms have been rather meager. Grafts of embryonic mammalian gonads to adult hosts of the opposite sex (*2*) have given negative or nearly negative results. Hormones of adults, when given to pregnant animals, have produced marked effects on the fetal reproductive tracts but inconsistent effects on the gonads. Recently MacIntyre (*3*), by grafting embryonic rat gonads in pairs to castrated adult hosts, has demonstrated that, when an ovary is grown with an embryonic testis, differentiation of the ovary is suppressed, while the testis is unaffected. Similar experiments on the rabbit by one of us (*4*) have produced the same result.

Wolff and his coworkers (*5*) have cultured embryonic duck gonads together in male-female pairs. In these experiments the ovary proved to be the dominant gonad, and the testis was suppressed.

It was felt that such cultures of embryonic mammalian gonads might be of some value as a control on the grafting experiments, inasmuch as cultures provide an environment more nearly free of extraneous hormones than adult hosts.

We therefore undertook a series of cultures of embryonic mammalian gonads. Both rabbit and rat embryos were used. The cultures were grown in hollow ground slides. We used plasma clots and embryonic extract as a culture medium after attempts with synthetic media failed. The embryonic extract was prepared from the anterior (gonad-free) halves of 11-day chick embryos, the plasma from heparinized blood of castrated rabbits. Gonads for culturing were obtained from embryos of the desired age and were grown in cultures for 4 to 18 days.

The 56 cultures were distributed as follows: male-female combinations, 17; male-male, 8; female-female, 10; single male, 9; single female, 8. There were also four cultures of gonads recovered at indifferent stages. Rabbits and rats gave the same results. No heteroplastic combinations were attempted.

Embryonic testes usually grew and differentiated well in all combinations. The seminiferous tubules were well formed and contained spermatogonia, some of which were degenerating, as they normally do. The differentiation was never equal to that occurring in a similar period of normal development but, in most cases, was well advanced over the differentiation that had occurred at the time of explanation.

Embryonic ovaries, on the other hand, only grew and differentiated in 19 of 35 cultures. When cultured alone or in combination with other ovaries, those that did grow produced some cortical differentiation. There were cell nests, occasional structures suggestive of primordial follicles, some proliferation of interstitial cells, and the retention of a cuboidal epithelium, which might be interpreted as a germinal epithelium. When explanted with testes, the ovaries which grew were always retarded in development in comparison with those cultured in the absence of the male gonad. None of them developed cell nests or other indications of cortical structures. In three instances there were indications of a masculinizing effect, as shown by the development of structures suggestive of testicular cords in medullary portions of the cultures. MacIntyre has suggested that such cords may in fact be "converted follicles of cortical or secondary sex cord origin." In either case, differentiation of the ovary was altered when the ovary was cultured with a developing testis. The differentiation of the testis, on the other hand, was not affected by the presence of the ovary.

These experiments (*6*) appear to support the findings obtained by grafting embryonic gonads. As the embryonic ovary is not affected in its development when grafted to the adult male, even if grown in the host testis (*7*), we suggest that it is probable that the embryonic testis produces a substance or "hormone" capable of modifying ovarian development and that this substance is not identical with the adult testicular hormone.

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2 June 1958

Ultraviolet Mitigation of X-ray Lethality in Dividing Yeast Cells

Abstract. The lethal effect of x-rays on dividing yeast cells can be decreased by small ultraviolet exposures delivered before or after x-ray exposure. This mitigating action can be decreased by exposure to visible light concomitant with photoreactivation of ultraviolet lethality. The results suggest considerable overlap between x-ray and ultraviolet lethality sites in dividing cells.

In the course of a study of the molecular and anatomical nature of the sites sensitive to lethal irradiation in dividing yeast cells, different combinations and permutations of x-rays, ultraviolet (UV), and visible light (VL) were employed. Depending upon the radiation and the sequence of administration, both coupling and uncoupling effects were observed. One such effect is the ability of UV either to protect or to reactivate x-rayed dividing yeast cells (that is, cells in division when irradiated).

Although the results to be described were obtained with a nonrespiring strain of haploid *Saccharomyces cerevisiae*, SC-7(ρ), qualitatively similar results were obtained with the parental, respiring diploid strain, SC-6, and the respiring haploid strain SC-7 from which SC-7(ρ) was derived. The mitigating effects were largest in SC-7(ρ), comparable in SC-6, and small but present in

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

SC-7. Cells exposed to x-rays (55 kv peak; unfiltered emission from a 1 mm Be window tube; dose rate 30.2 krad/min) were spread on YED agar surfaces (0.5 percent Difco yeast extract, 1 percent dextrose, 2 percent agar); the same technique was used for UV exposure (three low-pressure, 8-w germicidal Hg lamps; UV flux, 21 erg/mm² sec) or the cells were exposed while being agitated in 0.05*M* KH_2PO_4 buffer solution. Photoreactivating VL exposures were performed in the setup previously used for photolethality studies with SC-7(ρ) (*1*, *2*), except that the cell suspension was maintained at 30°C, and a 500-w projector was used. Although strain SC-7 is also sensitive to visible light, appropriate precautions were observed to avoid both incidental photolethality (*1*) or photoreactivation during the course of the experiments, or both. The criterion of survival was formation of visible colonies after 5 days' incubation at 30°C.

Curves *a* and *b* of Fig. 1 are the x-ray and UV survival curves, respectively, for a population of SC-7(ρ) harvested after overnight growth on YED agar. As was previously shown (*3*), in general the survival curve resulting from ionizing irradiation is the sum of an exponential and a sigmoid curve, the former reflecting the survival of interdivisional cells and the latter corresponding to dividing cells. It is noted that the UV survival curve in Fig. 1 has an inflection point at a survival level which appears to correspond to the inflection point in the x-ray survival curve, suggesting that dividing cells are less sensitive to UV, as well as to x-rays, than interdivisional cells.

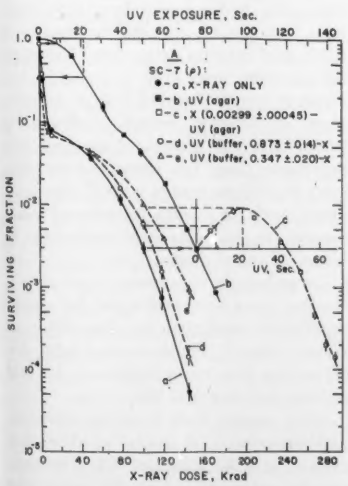

Fig. 1. Equivalence between pre- or post-UV exposure in increasing the survival of x-rayed dividing haploid yeast cells. A typical description of a curve like that for *c* means that a pre-x-ray exposure reduced the survival to 0.003 and that this was followed by a graded series of UV exposures. Standard errors are shown where larger than the plotted points (also in Fig. 2).

There is conflicting information in the literature relative to the compound nature of the UV survival curve (*4–6*) except in those instances in which the preparation of the cells was such as to insure a homogeneous, interdivisional cell population (*7*, *8*). Recently we have shown (*9*) that the inflection in the UV survival curve results from the presence of the same moieties displayed in the case of x-rays, although the inflection in the former case is not as pronounced because the curves for both moieties are sigmoid. In addition, we have proved (*9*) that the lesser UV sensitivity of dividing yeast cells results from basic changes in site sensitivity attendant with division and are not due, for instance, to increased scattering or increased specific but non-active absorption of the 254-mμ irradiation. Curve *c* resulted from a single x-ray exposure which reduced the survival to 0.003 followed by a graded series of UV exposures. Since the pre-x-ray dose was large enough to kill essentially all the interdivisional cells, *c* suggests that dividing cells are first reactivated by 3X before additional inactivation is produced by the UV. (The UV exposure sequence of *c*, when repeated with plate covers left on, produced neither additional killing nor reactivation.)

That this mitigating action of UV is independent of the sequence of administration is evidenced by curves *d* and *e* Fig. 1, and by curve *e*, Fig. 2. For the first two curves, small UV exposures were followed by graded x-ray exposures; each curve clearly shows that its initial portion lies below the x-ray-only curve while the reverse is true for its final portion. Further, there is quantitative agreement between the protection afforded by pre-UV and the reactivation resulting from post-UV exposures. Curve *e* of Fig. 2 shows that the mitigating UV exposure can be given during the x-ray exposures with results equivalent to those of the preceding cases.

In Fig. 2, curve *b* resulted from a maximally protective UV dose and is functionally similar to *a*, the dose-reduction factor being 0.77. Since in the case of VL photoreversal of UV lethality in yeast, dose-reduction factors of from 0.4 to 0.65 have been reported (*5*, *8*), the value of 0.8 observed in this case is significant particularly in view of the general injurious nature of UV exposure.

That UV protection is also photoreversible by VL is shown by curve *c* in Fig. 2. In this case, the pre-UV exposure was followed by a maximally reactivating VL exposure; however, the dividing cell portion of *c* lies below that of *b*, indicating that VL reverses the UV protection of x-ray lethality as well as UV lethality. That UV protection is temperature stable and that curve *c* resulted primarily from the effect of VL is shown by *d*, for which case the exposure and temperature sequence was the same as that for *c* except that VL was omitted.

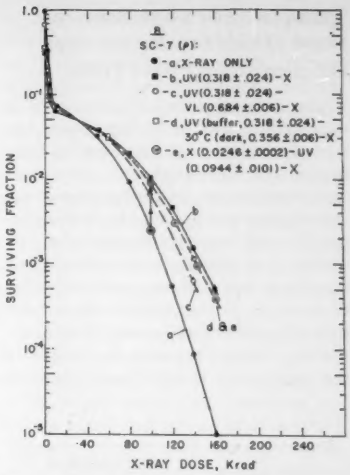
B
SC-7 (ρ):
●-a, X-RAY ONLY
■-b, UV (0.318 ± .024)-X
○-c, UV (0.318 ± .024)-VL (0.684 ± .006)-X
□-d, UV (buffer, 0.318 ± .024)-30°C (dark, 0.356 ± .006)-X
⊖-e, X (0.0246 ± .0002)-UV (0.0944 ± .0101)-X
SURVIVING FRACTION
X-RAY DOSE, Krad

Fig. 2. Photoreversal of the UV protection of x-ray lethality in dividing haploid yeast cells. Descriptions of the treatment sequences are as explained for Fig. 1.

These results are consistent with a number of others (*9*) which support the view that the sites of action of lethal irradiation are chromosomal deoxyribonucleic acid. In addition, this mitigating effect of UV is reminiscent of cytogenetic observations in *Tradescantia* pollen tubes (*10*) and in *Drosophila* sperm (*11*) where it was observed that pre- or post-UV decreased the observable number of x-ray chromosome breaks.

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9 July 1958

Quantitative Relations between Stages of Leaf Development and Differentiation of Sieve Tubes

The differentiation of xylem cells in vegetative apices of *Coleus* shoots was recently studied (*1*). Physiological techniques were combined with anatomical ones with the aim of getting anatomical information which would be both quantitative and regularly reproducible. By means of large-sample, round-the-clock collecting, this aim was achieved. One of the most striking results was the discovery that there was a very close quantitative relation between the length of the leaves and the particular stage of xylem differentiation occurring within the leaves. This report (*2*) presents similar data, obtained from the same and later collections, on differentiation of sieve tubes in young leaves of *Coleus*.

Materials and methods were the same as those used by Jacobs and Morrow (*1*), except that no clearing was used in the confirming collections.

The size of a *Coleus* leaf (as measured by its length) was as strictly related to the initiation and subsequent differentiation of sieve tube elements as was previously found for xylem. The first sieve tube appeared in the leaves of the second pair below the apex, when these leaves reached a characteristic length.

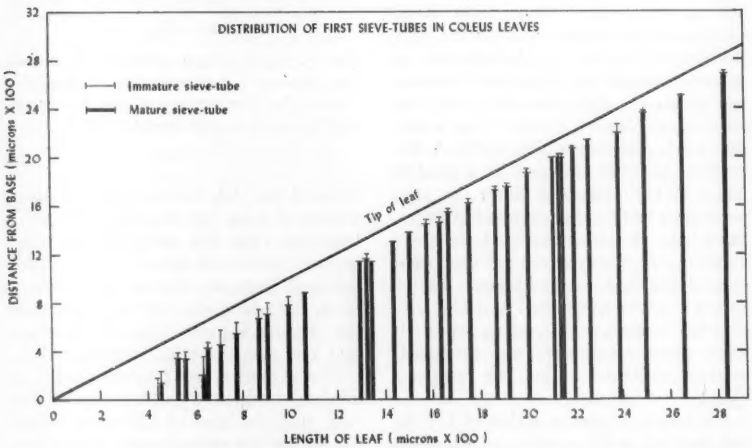

Fig. 1. Longitudinal distribution of sieve tubes within the main vein of young *Coleus* leaves. Each solid vertical line represents the sieve tube of a different leaf.

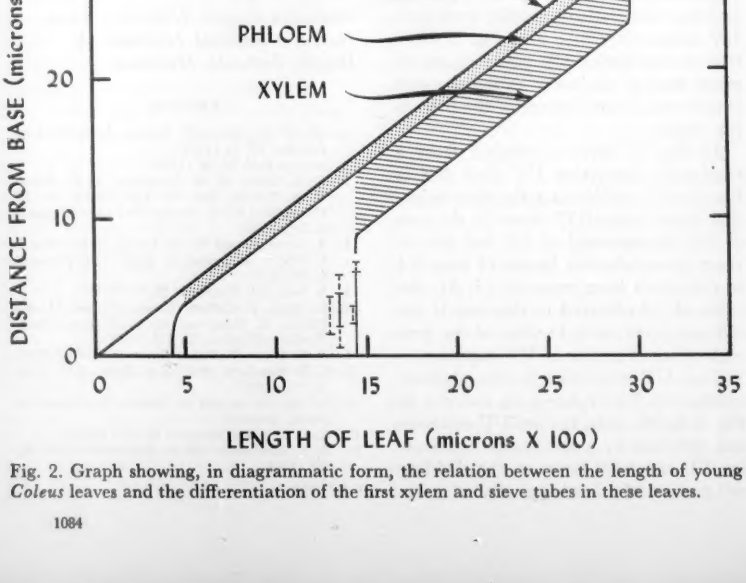

Fig. 2. Graph showing, in diagrammatic form, the relation between the length of young *Coleus* leaves and the differentiation of the first xylem and sieve tubes in these leaves.

In a given leaf, the first sieve tube differentiated quickly, in terms of increasing leaf length, to within 142 μ of the leaf tip—a position which it maintained with remarkable constancy while the leaf grew thousands of microns more (Fig. 1) and became, successively, a member of the third and then of the fourth leaf pair from the apex of the shoot. Examination of many leaves shorter than 400 μ showed no sieve tubes in any one of them. In contrast to the xylem, which first appears in the leaf at an isolated locus (Fig. 2), sieve tubes differentiate continuously upward from the stem (Fig. 1).

We found no sudden jump in differentiation of the sieve tubes at any leaf length studied. In this respect, sieve tubes were unlike the xylem, which showed a sudden acropetal jump at the time the isolated xylem strands first connected basipetally with the mature vascular tissue of the main stem. This acropetal jump of the xylem, which occurs at a leaf length of about 3000 μ, brings the xylem a few microns distal to the sieve tubes. The relative position and differentiation of these two cell types in leaves of increasing length are shown in Fig. 2.

Much evidence has been presented (*2*) that auxin from the young leaf is the normal limiting factor for the differentiation of xylem cells. The contrasting pattern of differentiation of sieve tubes suggests that the latter are normally limited by a factor moving upward from the more mature portions of the shoot. It is appropriate that it is in leaves 0.4 and 1.3 mm long that these cells, specialized for the transport of foods and mineral salts, should start to differentiate, since this is roughly the range of lengths beyond which ordinary physical diffusion would inadequately provide for the growth of the leaf primordium. This last consideration suggests that these results with *Coleus* will apply, with no change in order of magnitude, to vascular differentiation in leaves of other genera.

Large-sample collections made in subsequent years have confirmed the above-mentioned findings. In our clone of *Coleus blumei,* the first sieve tube differentiates in a young leaf when the leaf is from 400 to 450 μ long.

With respect both to xylem elements and sieve tubes, it is now evident that cells in specific stages of differentiation can be collected simply by measuring and collecting leaves of specific lengths. This discovery provides the experimental anatomist with a particularly powerful research tool.

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17 March 1958

Changes in Tryptophan Peroxidase Activity in Developing Liver

Some enzymes found in adult mammalian liver are absent from fetal liver. These enzymes are present in low activity at the end of gestation, and they increase rapidly to adult levels in a matter of hours or days after birth. This developmental pattern was first demonstrated for glucose-6-phosphatase (*1*); more recently it has been shown for phenylalanine hydroxylase, tyrosine-oxidizing enzymes, and uridine diphosphoglucuronic acid transferase (*2*). The questions arise: What mechanisms control the appearance of these enzymes late in gestation? What factors control the dramatic increase in activity which occurs after birth? One suggested mechanism is that of substrate induction. Knox reported that injection of L-tryptophan into normal adult rats or into adrenalectomized animals caused a transient increase in activity of liver tryptophan peroxidase (*3*). Knox presented evidence that the effect depended upon substrate induction.

To assess the possible role of substrate induction in the development of enzymes, we studied liver tryptophan peroxidase in the guinea pig, measuring levels of activity and the effect of L-tryptophan injection in fetal and postnatal stages up to the adult (*4*). This survey of tryptophan peroxidase revealed that, as with glucose-6-phosphatase, two distinct changes occur during development: an initial appearance of activity late in gestation and a rapid increase to adult levels after birth (Fig. 1). We found that injection of L-tryptophan into the fetus or into the mother before term had no effect on fetal liver tryptophan peroxidase activity. Injection of L-tryptophan in combination with ACTH or ACE also had no effect. Injection of a term fetus, *in utero* or after delivery by section, resulted in a small increase in fetal liver activity. A newborn guinea pig, after injection, showed a similar small increase. Twenty-four hours after birth, when liver tryptophan peroxidase activity had attained adult levels, the increase in activity following injection was as great as in the adult (Fig. 1).

As Knox has shown, the controlling mechanism increasing tryptophan peroxidase activity in adult liver after L-tryptophan injection is substrate induction (*3*). The relative refractoriness of fetal liver to L-tryptophan suggests that substrate induction is not the rate-limiting mechanism controlling the changes in enzyme activity observed during development.

In brief, the observations discussed above were made in the following manner. Assay of tryptophan peroxidase activity was carried out in 12.5-percent homogenates, as described by Knox (*5*). All assays were done on single livers. Conversion of L-tryptophan to kynurenine was measured. This is a two-step reaction; the first step is catalyzed by tryptophan peroxidase, the second, by formylase. Formylase is not rate-limiting in the over-all reaction in adult or fetal guinea-pig liver homogenates, for formylkynurenine, the product of the first step, does not accumulate. Also kynurenine is not metabolized in such homogenates, so the over-all conversion of L-tryptophan to kynurenine is a measure of tryptophan peroxidase activity.

To study the effect of L-tryptophan on liver tryptophan peroxidase activity, an animal was given 1 mmole of L-tryptophan intraperitoneally for each 200 g of weight. After 5 hours the animal was sacrificed by cervical dislocation, and the liver was assayed. Subcutaneous injection of L-tryptophan in the adult was as effective as intraperitoneal injection in raising tryptophan peroxidase activity. Injection of saline was without effect.

L-Tryptophan was injected into fetuses *in utero* in amounts proportional to the estimated weight. The mother was anesthetized with diethyl ether, a paramedian abdominal incision was made, and the fetus was injected intraperitoneally through the uterine wall. After 5 hours the mother was sacrificed, the fetuses were delivered by hysterotomy, and the livers were assayed. Anesthesia and laparotomy alone did not increase maternal liver tryptophan peroxidase activity. Intraperitoneal injection of L-tryptophan into the pregnant animal or into the fetus increased maternal liver tryptophan peroxidase activity about fivefold without affecting fetal liver activity. In all cases the injected fetuses seemed to be normal at the time of sacrifice.

It should be emphasized that the deficit of tryptophan peroxidase activity observed in fetal liver is due to absence of the active enzyme and not to a deficiency of a heat-stable cofactor or to the presence of an inhibitor in the homogenate. This conclusion was reached because the addition of fetal liver homogenate to adult liver homogenate had no effect on the activity found in the latter. Also, addition of a heated extract of adult liver failed to stimulate activity in fetal liver homogenates.

Some enzymes which have no activity in fetal liver until the end of gestation have been found to have little or no activity in certain hereditary diseases (*6*). It has been suggested (*1*) that such a disease can be viewed as a persistence of the fetal condition into postnatal life. One might predict that an inherited deficit will be discovered for each enzyme with a developmental pattern like tryptophan peroxidase. However, an inherited deficit of an enzyme necessary for fetal metabolism would probably elude discovery

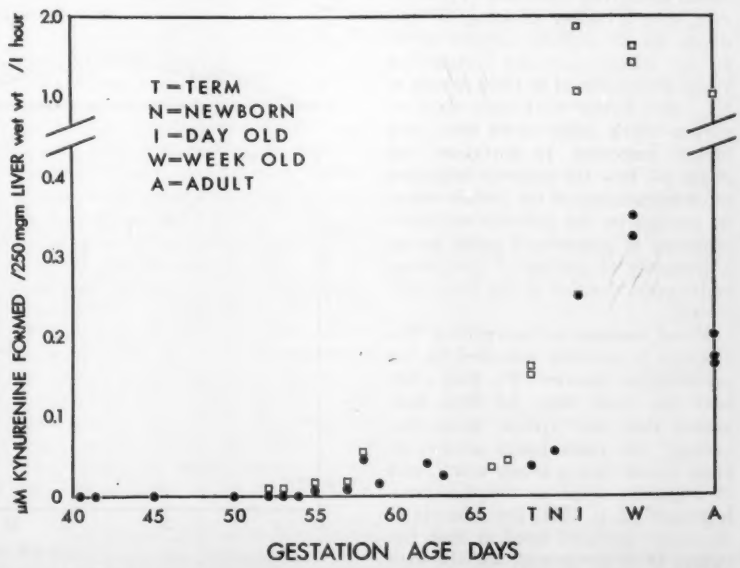

Fig. 1. (Solid circles) Tryptophan peroxidase activity; (squares) tryptophan peroxidase activity 5 hours after injection of 1 mmole of L-tryptophan per 200 g of weight.

because of the likelihood of intra-uterine death. Though, as yet, no inherited disease characterized by a deficit in tryptophan peroxidase activity has been described, a case reported by Baron is suggestive (*7*).

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29 May 1958

Psychological Brightness Reduction of Simulated Flashes from a Polyhedral Satellite

Abstract optical properties (such as brightness, frequency, and duration) of solar flash reflections to be expected from a polyhedral satellite have been discussed extensively elsewhere (*1*). However, since a leading advantage of such design for an artificial satellite would be the relative ease and certainty of visual observation of it, there remain to be studied further the human visual reactions which might result from such optical properties. In particular, one might ask how the apparent brightness or conspicuousness of the satellite would be affected by the reflected sunbeam's consisting of intermittent pulses having a frequency of perhaps 10 per second and a pulse duration of less than 0.001 second.

Visual response to intermittent illumination is generally described by two psychological theories (*2*). First, Talbot's law states that, for flash rates greater than the "critical flicker frequency," the fused image always appears fainter than a steady source, and of brightness equal to the time-mean brightness (*3*, p. 118). For example, if the image appeared fused at flash frequency of 10 per second, and the flash durations were 0.001 second, the image brightness would be 0.001/0.1, or 1/100 of its steady brightness—that is, it would be reduced by five stellar magnitudes.

But the proper applicability of Talbot's law depends on the flash rate's being above the critical frequency. This critical rate has been extensively measured for various colors and intensities of light. Curves plotted by Hecht (*4*) show that, for night (rod) vision, the critical flicker frequency is about 15 per second, while for fainter and redder sources it may decrease to 10 or below. Hence, although Talbot's law giving a time-mean brightness would hold for polyhedral satellites flashing more than 15 times per second, for lower flash rates it would not be strictly applicable.

It has been shown (*3*, p. 138) that for such flash rates below the fusion frequency the apparent brightness of the flickering light increases continuously with decreasing frequency. Indeed, for day (cone) vision and light-to-dark ratios of at least 1 to 1, the enhancement effect, discovered by Bartley, gives, for a frequency of about 9 per second an apparent brightness actually greater than the steady brightness, by a factor equal to the reciprocal of that given by Talbot's law. However, the Bartley effect for a light-to-dark ratio as low as the expected 1 to 100 of a polyhedral satellite seems not to have been investigated by the psychologists.

Nevertheless, it appears certain that, for frequencies below that of fusion, the brightness above the time-mean would generally increase with decreasing frequency, so that, for zero frequency, it would always equal the steady brightness. As an approximation hypothesis one might assume, for a constant light-to-dark ratio, a linear logarithmic increase of brightness with decrease of frequency—that is, a linear variation of apparent stellar magnitude in proportion to frequency below that of fusion. Thus, for the above example in which brightness at the fusion frequency of 10 per second was reduced by five magnitudes, the reduction at a frequency of 4 per

Table 1. Diminution of the intermittent image for three typical flash rates.

Star	Steady magnitude	Flashing magnitude	Dimming
Run No. 1 (frequency, 3.3/sec; duration, 0.00152 sec)			
Jupiter	−1.4	+1.2	+2.6
Vega	+0.1	+1.8	+1.7
Arcturus	+0.2	+1.2	+1.0
Saturn	+0.5	+2.7	+2.2
Altair	+0.9	+1.8	+0.9
Spica	+1.2	+3.8	+2.6
Mean dimming			+1.8 ± 0.2
Run No. 2 (frequency, 6.2/sec; duration, 0.00081 sec)			
Jupiter	−1.4	+0.7	+2.1
Arcturus	+0.2	+1.9	+1.7
Spica	+1.2	+3.4	+2.2
Mean dimming			+2.0 ± 0.1
Run No. 3 (frequency, 7.7/sec; duration, 0.00065 sec)			
Jupiter	+1.4	+1.4	+2.8
Arcturus	+0.2	+2.2	+2.0
Spica	+1.2	+3.3	+2.1
Mean dimming			+2.3 ± 0.2

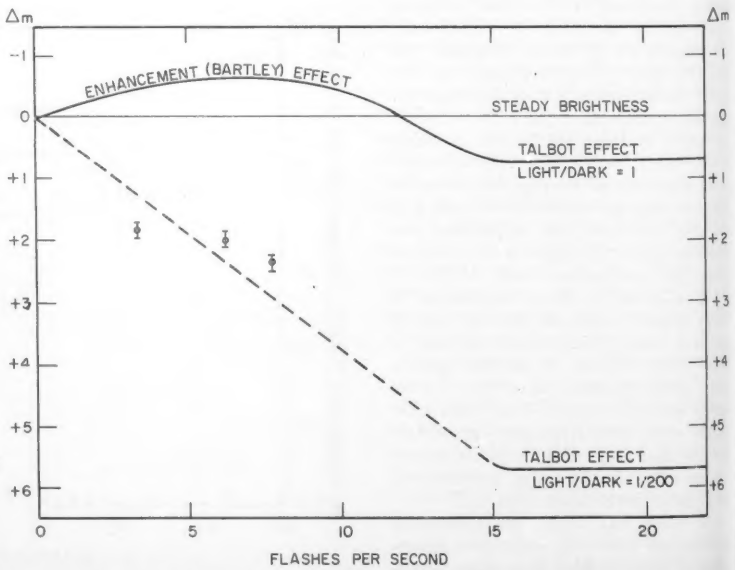

Fig. 1. Variation of apparent stellar magnitude with flash frequency for critical (fusion) frequency of 15 per second.

second might be expected to be about two stellar magnitudes.

Experimental measurement (*5*) of the actual reduction of apparent brightness under such conditions was carried out as follows. Intermittent solar reflections from the surface of a polyhedral satellite were simulated by viewing various planets and stars through the interception of a rotating metal disc of about 10-in. radius from which had been cut a sector ⅓ in. wide; this gave a clear opening effectively 1/200 the total area of the disc. The intercepted, flashing image of one star—say Arcturus—viewed with one eye was compared in brightness to the image of another—say Spica—viewed simultaneously, without interception, with the other eye. From the known magnitudes of each star the diminution of the intermittent image was estimated for three typical flash rates, with the results shown in Table 1. For this the flash frequencies and durations were derived from the rotational rate of the disc, as measured with a tachometer.

The graph (Fig. 1) shows these three values of brightness reduction compared to theoretical curves of such reduction for sources, like stars, for which the intermittent images would appear fused for frequencies 15 per second.

For a polyhedral satellite rotating once per second, the mean duration of a reflected sunbeam would be 0.0009 second, and this would vary inversely as the spin rate (*1*). If, also, the complete polyhedron had 856 faces, the mean frequency would be 2 per second, and this would vary directly with both the spin rate and the number of faces. Since a spherical reflector is optically equivalent, for solar reflection, to a polyhedron having about 200,000 faces (the number of angular solar areas on a sphere), the optical gain from use of the 856-face polyhedron would be about 250, or six stellar magnitudes. Since the present measures indicate a visual reduction, in this case, of only about one magnitude, the net visual gain from use of a polyhedral rather than a spherical satellite would be five stellar magnitudes.

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24 June 1958

Physicochemical Study in Water of a Mucoprotein with Virus-Inhibiting Activity

Abstract. Human urinary mucoprotein precipitated with cetyltrimethylammonium bromide and suspended in distilled water has a light-scattering molecular weight of 2.8×10^6, an intrinsic viscosity of 225, a refractive index increment of 1.73×10^{-4}, and an absorption coefficient ($E^{1\%}_{1cm}$) of 11.4. The molecule is therefore smaller than that of the mucoprotein isolated by Tamm and Horsfall but retains its biological activity.

A mucoprotein derived from human urine which reacts with influenza, mumps, and Newcastle disease virus has been isolated and characterized physicochemically by Tamm and Horsfall (*1, 2*). This fibrous mucoprotein, soluble in distilled water and isolated as a single component in the ultracentrifuge, was found from ultracentrifuge and diffusion measurements (*2, 3*) to have the very large molecular weight of 7×10^6 and to be highly asymmetric.

A mucoprotein with similar antiviral properties and chemical analysis has been isolated by Di Ferrante (*4*), by a different method. In the ultracentrifuge this is a single component whose sedimentation constant in water suggests that its molecular weight is considerably smaller than that of the mucoprotein isolated by Tamm and Horsfall.

The work discussed in this report (*5*) is an attempt to characterize physicochemically the mucoprotein isolated by Di Ferrante and to indicate its relationship to that of Tamm and Horsfall. The large molecular weight, the high asymmetry, and the poor solubility in salt solution render light scattering the method of choice in the investigation of this mucoprotein.

The mucoprotein was prepared by the method of Di Ferrante (*4*) from the urine of two male diabetic patients. Ten grams of cetyltrimethylammonium bromide were added to 18 lit. of urine. After standing 3 days in the cold, the precipitate was removed in a continuous-flow refrigerated Sharples supercentrifuge and washed four times with ethyl alcohol saturated with sodium chloride. The precipitate was suspended in, and dialyzed against, distilled water and clarified by centrifugation. The supernatant was brought to 0.58*M* sodium chloride, and the new precipitate was removed, redissolved, and dialyzed in water. The dialysis was continued with frequent changes for 3 days, and then the precipitate was clarified by centrifugation. All investigations reported here were made on this distilled water solution.

Through the kindness of Igor Tamm, I investigated the biological activity of two samples of this mucoprotein in his laboratory at the Rockefeller Institute for Medical Research and found these to exhibit a hemagglutination-inhibiting activity of 0.013 μg for a fresh sample of mucoprotein and of 0.1 μg for a sample which has been standing at 4°C for several weeks. This activity is expressed as amount (in micrograms) of mucoprotein required for complete inhibition per hemagglutinating unit of heated Lee virus (56°C for 30 minutes).

The intensity of light of wavelength 436 mμ scattered from serial dilutions of mucoprotein in a cylindrical cell at angles of from 26° to 135° from the direction of the incident beam was measured in a Brice-Phoenix light-scattering photometer and recorded in the form of a Zimm plot. The Zimm plot is, of course, highly distorted (*6*) in the case of media of low ionic strength, and a dissymmetry of less than unity was observed at the highest concentrations used. The extrapolated curve of scattering at zero angle which determines the interaction constant, and the intercept of this curve with the axis of KC/R_θ, which yields the molecular weight independent of the shape of the molecule, are not distorted. The weight average molecular weight was determined by this method to be 2.8×10^6. The interaction constant B is $+0.88 \times 10^{-3}$, indicating that water is indeed a good solvent for the mucoprotein. The solution did not fluoresce at this wavelength and showed a small depolarization.

Viscosity data (Fig. 1) extrapolate linearly at low concentrations to an intrinsic viscosity of 225. The high intrinsic viscosity suggests a highly asymmetric molecule. In view of the electroviscous effect, it would be misleading to calculate an axial ratio from these data. The intrinsic viscosity of a sample of mucoprotein prepared by the method of Tamm and Horsfall was found to be 630.

The refractive index increment (Fig. 1) is 1.73×10^{-4} and remains constant, over the concentration range tested, from $0.6 + 10^{-3}$ to 2.0×10^{-3} g/ml. This is lower than the usual values for proteins but is in line with the values reported for mucoproteins.

The ultraviolet absorption spectrum (*p*H 5.7) has a single major peak at

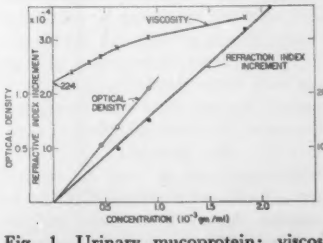

Fig. 1. Urinary mucoprotein: viscosity, optical density, and refractive index increment as a function of concentration.

31 OCTOBER 1958

278 mμ, with shoulders at 284 and 290 mμ. There is a suggestion of a component at 260 mμ. The visible and near-infrared spectra show no peaks from 340 mμ to 1000 mμ. The optical density at 278 mμ follows Beer's law (Fig. 1) throughout the concentration range tested. The absorption coefficient $E^{1\%}_{1\,cm}$ is 11.4. The absorption spectrum of a sample of mucoprotein prepared according to the method of Tamm and Horsfall is found to be identical with this.

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9 July 1958

Artificially Induced Circulation of Lakes by means of Compressed Air

Abstract. Turbulence induced by air bubbles causes circulation in small thermally stratified lakes. Tests were made under summer and winter (ice-cover) conditions. Homoiothermal conditions, isometric concentrations of phosphorus, and increases of dissolved oxygen were achieved, at various rates of treatment. The application of the technique for lake management and in studies of lake dynamics is suggested.

Stratified lakes in the Temperate Zone present certain problems. (i) They accumulate astonishing amounts of phosphorus in their lower regions. At the same time they exhibit a dearth of this element in the euphotic zone (*1*). (ii) In some there is no vernal circulation, as there is in typical dimictic lakes. (iii) In the winter some tend to have serious oxygen deficits under the ice cover, often resulting in the winterkill of fish fauna. These problems appear to be rectifiable by some means of induced circulation (*2–4*). The actual circulation of lake basins with water pumps has been demonstrated (*3*), and other techniques, such as the use of the turbulent effect of compressed air, offer promise.

Compressed air is used in natural waters, chiefly for reoxygenation (*5*) or to remove the ice from water surfaces (*6*). It was the purpose of the study described in this report to test the effect of air-induced circulation in stratified lakes.

In tests under summer conditions, compressed air was used to bring hypolimnetic water up into the euphotic zone. A small experimental lake, Sawmill Pond, with a maximum depth of 7.1 m and an area of 1250 m² was used. Air was delivered through small perforations spaced along the length of an air conductor, suspended just above the bottom. The daily rate of flow was 101 lit. (1 atm, 20°C) per cubic meter of lake volume. The effect was immediate and pronounced. An almost homoiothermal condition was observed after 4½ hours of treatment (Fig. 1). The concentrations of soluble phosphorus became isometric with depth. Prior to treatment they exhibited the typical high concentrations in the 2- to 3-m zone. It was observed that the absolute content of the total phosphorus in the upper 2 m was higher in every case than the mean of the pretreatment values.

In an experiment conducted in Tub Lake (0.7 hectare) in which lower daily rates of treatment (5.6 lit. of air per cubic meter of lake volume) were used, it was shown that radioactive phosphorus which had previously been placed in the hypolimnion could be brought to the surface (*7*). In this case the thermocline was lowered, but it retained its identity.

The amount of work theoretically required to compress the air to the necessary hydrostatic pressure (and hence to expand the rising bubble) was compared with the change in volume of the epilimnion resulting from the treatment. This was done in order to provide a basis for comparison of treatments in lakes of different sizes. The values obtained ranged from 8.17×10^2 g cm to 19.4×10^2 g cm for the work applied to each cubic meter of lake volume for each cubic meter of increase of the volume of the epilimnion.

Tests under conditions of ice cover were conducted with essentially the same physical installation. Daily additions of 3.4 and 1.9 lit. of air per cubic meter of lake volume were applied in two consecutive years on Katharine Lake (6.1 hectares). These applications maintained areas of open water continuously and concentrations of dissolved oxygen at about 7 and 2 parts per million, respectively. It should be emphasized that, under normal conditions, levels of oxygen concentration in this water are less than 3 parts per million and are periodically less than 1 part per million. It was noted that average water temperatures were reduced to as low as 0.7°C at the higher rate of treatment.

The force of the wind, exerted on the surface of a stratified lake, has a relatively small effect. An example of this is presented by Hutchinson (*8*) for Linsley Pond, where the thermocline of the lake was little affected by the hurricane of September 1938. By contrast, controllable forces, when applied in the manner described in this report, act from within the basin with, figuratively speaking, tornadic effect.

It is suggested that for the experimental limnologist the "air-lift" procedure can serve as a tool in the study of lake dynamics. He can achieve homoiothermal or isochemical conditions down to any contour level or can establish a thermocline in a desired position.

The technique affords a means of "intrafertilization" under certain conditions. Whether or not this effect is translatable into sufficiently large amounts of desirable end products—that is, increased zooplankton or fish production—cannot be

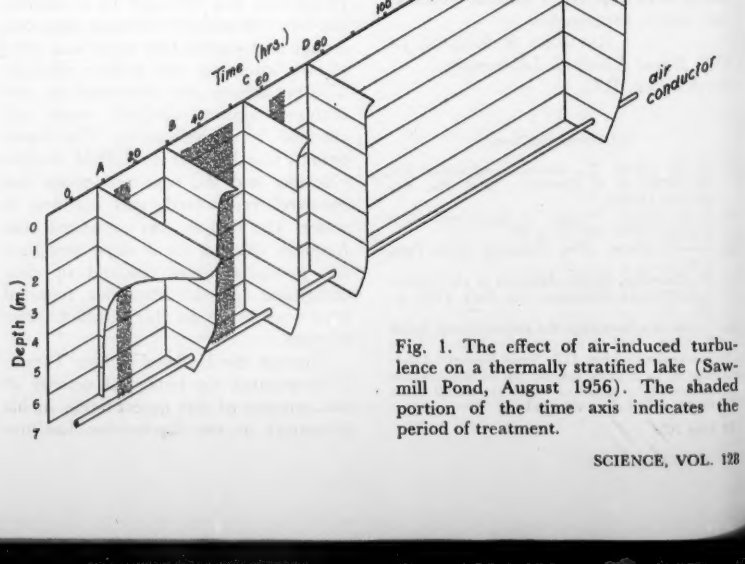

Fig. 1. The effect of air-induced turbulence on a thermally stratified lake (Sawmill Pond, August 1956). The shaded portion of the time axis indicates the period of treatment.

ascertained from these experiments. However, artificial circulation offers other possibilities for the management of lakes. One possibility is the assurance of the vernal circulation of "spring meromictic" lakes, in which trout could not ordinarily be held during the summer period.

This technique can be used to prevent winterkill in ice-covered lakes. However, many details, particularly with reference to the effect of low water-temperatures on the fauna, remain to be examined (*9*).

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14 August 1958

Thermocouple for Vapor Pressure Measurement in Biological and Soil Systems at High Humidity

All biological systems depend upon water regimes that are often delicately balanced with respect to the physical condition of the water. Water binding is determined by forces associated with bodies ranging upward in size from individual solute molecules, through colloidal particles, and on up to the larger solid surfaces bounding the system. The effect of binding energy on biological activity is expressible in terms of a colligative property of the water, such as vapor pressure. In addition, the effect of binding-energy gradients on the movement of water in biological systems is of immediate interest.

For example, the uptake of water by plant roots is restrained by forces associated with solute particles in the soil solution and also by forces based in the soil matrix which hold the water films on the soil surface. Both of these binding actions depress the vapor pressure of water in soil, and it has long been supposed that a measurement of this vapor pressure would give a good index of the suction that must be developed in the plant root to effect water intake. Unfortunately, the range of relative humidity of soil air that has agricultural significance lies above 99 percent and presents considerable difficulty with respect to measurement. Wet-junction thermocouples with adequate sensitivity (*1*) have been available, but problems connected with calibration and sample handling were not solved. The thermocouple-sample arrangement shown in Fig. 1 has evolved from tests of various designs and now makes possible precise relative-pressure measurements near saturation for a variety of sample materials. The method is based on the temperature difference between dry and wet junctions in the sample chamber. The dry junction follows ambient temperature, and the wet junction, through evaporation effects, responds to ambient vapor pressure.

In Fig. 1, *A* is the assembly as installed in the thermostat, and *B* is an enlarged view of the thermocouple. The insulating cover (1) helps to maintain the samples at constant temperature in the liquid bath (2). The masonite cover (3) supports a number of thin-walled brass test tubes (4). The thermocouple mount guides the couple into the sample container and makes it convenient to shift the couple from one sample to another. The mount consists of a cylinder of thin-walled brass (5) closed at the lower end with a disc of copper (8) and a copper tube (7) assembled with soft solder. The handle (6) is made of rigid plastic. The lead wires (11), have seven strands of 36-gage bare copper and have vinyl insulation of 0.1 cm outside diameter. The two lead wires make a tight fit in tube (7). The twisted strands extend a short distance (12) below the vinyl and are reduced to a single strand for an additional distance (13). Soft solder with low thermal electromotive force is used to join bare Chromel P (14) and Constantan (15) wire, 25 μ in diameter, and to attach the silver cylinder (16), which is of 0.185 cm outside diameter, with a wall 0.018 cm thick and 0.051 cm high. The thermocouple resistance is 20 ohms. A standard-size water droplet is obtained in the silver cylinder by submerging the cylinder in water and then rapidly lowering the vessel containing the water.

Sample containers are made of brass tubing (17) with end caps (18) of brass or plastic. The caps have a square shoulder and are prepared for use by dipping in hot universal wax. The fillet of wax thus left in the shoulder recess provides a vapor seal. Soil samples are prepared by filling the sample container with a closely fitting soil core and closing the ends with solid caps. Later, an end cap with a 0.9-cm hole is attached, and the container is supported upside down in a jig, while a central hole in the soil core is scratched out by a thin rotating tool. A cap (19) with a 0.6-cm hole is then attached, and the sample is inserted in the bath. Figure 1*A* shows a soil sample with the thermocouple in place. Vapor measurements of plant leaves are made by lining the sample chamber with leaf tissue. Measurements of aqueous solutions are made by supporting the solution on a filter-paper liner, including a paper annulus at the top of the chamber.

After placement in the bath, the vapor seal for the sample is accomplished by means of a water bag made from a rubber finger cot and supported on a plastic mount similar to the metal mount for the thermocouple. The measurement is made by inserting the thermocouple in the sample container. A steady electrical reading is usually obtained in from 10 to 30 minutes if the vapor condition of the sample is steady. A longer time is required at higher relative pressures. The thermocouple output is measured to an accuracy of 0.01 μv by means of the potentiometer arrangement described by Teele and Schuhmann (*2*). Precautions given by these authors for avoiding extraneous electromotive forces should be closely observed. Measurements thus far have been made at 25°C, with temperature fluctuations in the bath kept at less than $\pm 5 \times 10^{-4}$°C.

The thermocouples were calibrated at five points, each point being the vapor pressure of KCl at known osmotic pressure in the range from 5 to 65 bars. Values of osmotic pressure at 25°C for the standard solutions used in the calibration described above were obtained by use of the factor 13.33 bars of osmotic pressure per degree centigrade of freezing-point depression. The electrical output of the couples was proportional to the osmotic pressure. Sensitivities of the four couples expressed as microvolts per

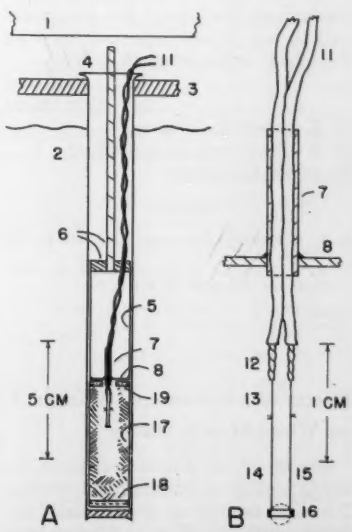

Fig. 1. Thermocouple and sample chamber for measuring vapor pressure.

bar of osmotic pressure were, respectively, 0.576 ± 0.004, 0.570 ± 0.004, 0.568 ± 0.004, and 0.562 ± 0.005. These sensitivity values for the separate couples are averages for determinations at five osmotic pressures. The standard errors measure the accuracy of proportionality between output, in microvolts, and osmotic pressure. The coefficient of variability of the voltage readings for five replicates of each of the KCl concentrations was determined for each of the thermocouples; the over-all average of these 20 coefficients was 0.5 percent. The highest variability occurred at the highest osmotic pressure for which the average coefficient of variability for the four junctions was 1.1 percent.

The calibration of a hygrometer that makes use of evaporative cooling depends on atmospheric pressure. For a given osmotic solution in the sample chamber of the couples here described, the rate of change of sensitivity with change in atmospheric pressure is constant but increases as the osmotic pressure of the sample is increased. The increase in sensitivity for a 10-mbar decrease in barometric pressure is 0.00145, 0.00155, and 0.00160 μv, respectively, per bar of osmotic pressure, for standard osmotic solutions of 5, 10, and 20 bars. Correction for change of atmospheric pressure from the value at calibration will not often be needed, but barometer readings should be taken so that correction can be made if necessary.

The physical condition of water in soil is usually specified in terms of equivalent membrane pressures, largely because measuring techniques employing membranes are available. With thermocouples which can be accurately calibrated in terms of relative pressure near saturation, it seems clear that the thermodynamic functions of free energy and activity will be more generally used for describing soil-water-plant systems.

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6 June 1958

Effects of Selenium and Vitamin E on White Muscle Disease

Reports of the pharmacodynamic interrelationship of selenium and vitamin E in liver necrosis of rats (*1*) and "exudative diathesis" of chicks (*2*) prompted the inclusion of this element in an experiment designed to study the factor or factors involved in the cause of white muscle disease, a myopathy in lambs and calves which results when legumes from certain areas are fed to the dams during gestation (*3, 4*). Since reports concerning the role of vitamin E in this disease are somewhat contradictory (*4, 5*), that vitamin was likewise included in this experiment.

Table 1. Scheme and results.

Ration supplement	Lambs	
	Affected	Not affected
Lot 1, control ration		
None	1	17
Lot 2, basal ration		
None	11	4
Lot 3, basal ration		
770 I.U. of α-tocopherol per ewe per week*	11	4
Lot 4, basal ration		
100 I.U. of α-tocopherol per ewe per day†	16	4
Lot 5, basal ration		
0.1 part of Se per million, calculated for the total ration‡	1	15

* Administered parenterally as *d*-α-tocopheryl polyethylene glycol 1000 succinate (*8*).
† Administered orally, as Myvamix (*8*), with the oats.
‡ Administered orally, as Na_2SeO_3, with the oats.

Lots of 12 ewes each were used in this experiment. The ration fed the control lot consisted of Ladino clover and alfalfa hay grown in relatively nonaffected areas, plus 0.25 lb of oats per ewe per day. The basal experimental ration consisted of Ladino clover hay from a severely affected area, plus 0.25 lb of oats per ewe per day. Supplements were given as indicated in Table 1. A preliminary trial indicated that vitamin E as injected maintained satisfactory blood levels in ewes.

The ewes were placed on the experimental regime 50 days after the bucks were placed with them, and the respective rations were continued for approximately 140 days, the termination being governed by the ages of the individual lambs. One of each pair of twins occurring in lots 1 and 2 was sacrificed soon after birth. These, and other lambs that died, in all lots, were necropsied. With a few exceptions, all of the others were necropsied at approximately 6 wk of age.

Analyses of the hays (*6*) fed in this experiment indicate levels of less than 0.1 part of selenium per million, the limit of the analytical method employed. Tocopherol levels in the hays and in the blood of both the dams and the lambs are being determined.

These results appear to indicate that selenium had a definite protective pharmacodynamic effect with respect to white muscle disease under the conditions of the experiment and suggest that a more comprehensive and critical investigation should be made of the role of this element in white muscle disease and other myopathies occurring in animals, including man (*7*).

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6. We acknowledge the assistance of W. W. Ellis, of the University of Wyoming, in determining the selenium content of the hays.
7. We thank Karl Folkers, of Merck and Company, for his advice and encouragement in connection with this experiment.
8. D. C. Herting, of Distillation Products Industries, kindly made available the Myvamix and the *d*-α-tocopheryl polyethylene glycol 1000 succinate used in these studies.

26 May 1958

Anaphylaxis in Passively Sensitized Guinea Pigs after Subcutaneous Eliciting Injection

Lethal anaphylaxis after a subcutaneous eliciting injection of homologous antigen has been reported relatively rarely. Recently it was shown that in actively sensitized guinea pigs an ultimately lethal but protracted anaphylactic shock can be regularly elicited by a subcutaneous injection of relatively large amounts of antigen (*1*). The signs of protracted shock include pruritus, dyspnea, bristling of fur, a fall in body temperature, and prostration. Symptoms first appear a few minutes after the eliciting injection (pruritus), but death may not occur until several hours have elapsed. At necropsy, the most consistent finding is stasis or hemorrhages of the intestine and stomach walls.

In the experiments to be described in this report, guinea pigs were passively sensitized by the intravenous route with graded amounts of guinea pig or rabbit antiovalbumin serum. Table 1 shows the results of subcutaneous injection of 50 mg of ovalbumin 19 to 20 hours after passive sensitization. In view of the lack

of information on the nature of all the types of antibodies capable of causing anaphylactic sensitization (*2*), passive cutaneous anaphylaxis (PCA) was chosen as the method for titration of both rabbit and guinea pig antisera used for passive sensitization. However, precipitin antibody nitrogen determinations were made on the rabbit antiserum for comparison with prior quantitative studies of systemic anaphylaxis (*2, 3*).

The results obtained with both guinea pig and rabbit serum show that when antiserum is injected 19 to 20 hours prior to the subcutaneous eliciting injection of antigen, the anaphylactic shock observed is of the acute type—that is, there is a swift lethal outcome in respiratory difficulty, and emphysema of the lungs is the striking observation at necropsy. Furthermore, over a limited range of sensitizing dosages, death occurs more rapidly with smaller amounts of antiserum used to prepare the guinea pig; thus within this range, the degree of prolongation is proportional to the amount of serum antibody previously injected. At the effective threshold, the guinea pig may die in acute shock or show acute symptoms of anaphylaxis and recover relatively swiftly or survive a severe acute reaction to suffer protracted anaphylactic shock.

When the antibody is injected intravenously just prior to the subcutaneous eliciting injection, the shock is protracted and usually mild. When, after a preparatory injection of antiserum 19 to 20 hours earlier, an additional amount of antiserum is injected just prior to the subcutaneous eliciting injection, prolongation of the anaphylactic shock may occur. This is probably different from the nonspecific protective effect of foreign sera (*4*) which was observed in our controls. (These controls were injected with 1 ml of normal rabbit or guinea pig serum immediately before the eliciting dose. Rabbit serum regularly provided a true protective effect; the sample of guinea pig serum was much less active.) The type of anaphylaxis observed is dependent on the amount of antiserum given 19 to 20 hours before and the amount injected just before the eliciting dose of antigen. With relatively large amounts of antibody injected the day before, additional amounts of antibody injected just prior to the eliciting injection do not affect the outcome, which is death in 25 to 45 minutes. In these animals, both emphysema of the lungs and stasis in the gastrointestinal tract are usually observed.

The protracted anaphylactic shock of guinea pigs is not a separate form of reaction but that which occurs in a sensitized animal shielded from the full extent of explosive early respiratory effects. It is similar to the anaphylactic shock observed in rats (*5*) and in some aspects

Table 1. Passive anaphylaxis in guinea pigs elicited by subcutaneous injection of 50 mg of egg albumin. Equal numbers of male and female Hartley guinea pigs, weighing from 450 to 550 g, were used. Responses in males and females were similar.

No. of guinea pigs	Amt. of antibody injected before eliciting injection*			Findings at necropsy‡			Deaths			Degree of shock in survivors§
	19–20 hr before		Just before (PCA units)†	Acute	Complex	Protracted	No.	Time (min)		
	PCA units†	Antibody N (μg)						Max.	Av.	
				Guinea pig pool I						
3	10,000		0	0	3	0	3/3	20	17	
5	5,000		0	0	2	1	3/5	25	18	M,S
5	2,000		0	2	3	0	5/5	20	14	
4	1,000		0	2	0	0	2/4	8	7	M,M
5	500		0	1	0	0	1/5	5	5	M,M,M,M
3	100		0	0	0	0	0/3			M,M,M
				Guinea pig pool II						
4	10,000		0	0	4	0	4/4	33	31	
5	2,000		0	2	0	0	2/5	6	6	S,S,S
4	500		0	2	0	0	2/4	5	5	M,M
4	10,000		10,000	1	3	0	4/4	47	39	
4	2,000		10,000	1	2	0	3/4	43	34	M
4	500		10,000	0	0	1	1/4	65	65	M,S,S
				Rabbit pool I						
2	200,000	750	0	2	0	0	2/2	25	23	
4	40,000	150	0	4	0	0	4/4	20	14	
4	10,000	37	0	3	0	0	3/4	8	7	M
3	2,000	7.5	0	0	0	0	0/3			M,M,M

* Antiserum was injected intravenously.
† A PCA unit is the amount of serum capable of sensitization for a threshold response (blueing 8 to 10 mm) unitage determined by twofold dilution titration with guinea pigs as test animals. In rabbit pool I, 1 unit = 0.0038 μg of antibody N, 200,000 units = 1 ml of serum. In both guinea pig pools, 10,000 units = 1 ml of serum.
‡ Acute, inflated lungs; Complex, inflated lungs and stasis in gastrointestinal tract; Protracted, stasis in gastrointestinal tract.
§ M, mild to moderate anaphylactic shock; S, severe anaphylactic shock.

resembles tuberculin shock. The guinea pig survives to undergo the whole syndrome—that is, pruritus, respiratory difficulty, bristling of fur, fall in temperature, and damage to gastrointestinal blood vessels. For example, it was found that sensitized guinea pigs which would die in acute anaphylaxis after a subcutaneous challenge will undergo severe or lethal protracted anaphylaxis if they are protected from the respiratory crisis by Pyribenzamine (*6*). It seems evident that the "protective" factor in guinea pigs challenged by the subcutaneous route is an "excess" of serum antibody presumably free in the circulation and rendered capable of such "protection" by the fact of slow absorption of antigen from a subcutaneous injection site. It is of additional significance that Opie found absorption of egg albumin from the local site of injection slower in the immune than in the normal animal (*7*).

Some unification of cellular and humoral theories of the mechanism of anaphylaxis (*8*) is possible on the basis of the data obtained. It is probable that circulating antibody is not a "protective" factor as much as it is a "prolonging factor." Its protection diverts the blow from the guinea pig "shock organ," and does so only when the challenging route is other than intravascular or when there is little antibody in the issues of the guinea pig (passive sensitization and immediate challenge).

The significance of these findings with regard to the problem of anaphylaxis in man caused by subcutaneous or intramuscular injection of antigenic material and the possible role of serotonin in protracted anaphylaxis of guinea pigs is currently under investigation.

SANFORD H. STONE
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29 May 1958

Meetings

Fifteenth International Congress of Zoology

The 15th International Congress of Zoology, under the able chairmanship of Sir Gavin de Beer, was recently completed. More than 1900 members of various branches of animal science gathered on 16 July at the Albert Hall in London to hear Sir Julian Huxley deliver the opening lecture, celebrating the centennial of Darwin's and Wallace's momentous contributions. It was altogether fitting that the surviving grandchildren of both illustrious zoologists could be present.

Sectional meetings of the congress were held in the British Museum of Natural History, the Imperial College of Engineering, and the Royal Geographical Society. Gracious hospitality was afforded by the University of London, the Zoological Society, the Palaeontology Association, the Wellcome Historical Medical Museum, the Royal Photographic Society, and many others. A great deal of hard work was done by the British hosts and their numerous committees, headed by Sir Alister Hardy, C. F. A. Pantin, H. R. Hewer, and N. D. Riley. Arrangements were made for unusually interesting symposia; for expeditions to the Linnean Society, to Downe House, and to the Whipsnade Zoo; for receptions at the Zoological Gardens and the Natural History Museum; and for a concert of the London Philharmonic Orchestra under the direction of Sir Adrian Boult. Delegates and members from all over the world were greeted personally by the British Home Secretary, Viscount Hailsham.

Taxonomists will be heartened to learn of the progress made by the International Commission for Zoological Nomenclature—progress which has lead to the establishment of a permanent body to consider conflicts in terminology and classification. A heavy program of taxonomic recommendations and changes was accomplished in the week preceding, and during the congress. Nevertheless, the numerous wrangles over minutiae of nomenclature must have caused Darwin to turn over in his grave. Experimental zoologists seem to prefer to go calmly ahead, leaving systematics to a vociferous minority.

Scientific highlights included symposia on the "Biology of Whales," "Geographical Speciation," and "Behavioral Ecology" and what was described as a scintillating paper, by J. Millot of Madagascar, on the "Anatomy of the coelacanth *Latimeria chalumnae* Smith." There were well-planned sessions on the teaching of zoology in different parts of the British Empire and in European countries and outstanding sessions on paleozoology, osmoregulation, neurosecretion, and the ancestry of man. A series of papers dealing with publications in zoology was somewhat lacking in intellectual content and offered no forward thinking on how to simplify the vast maze of biological literature. Contributors went to some pains to explain how good their journals had been for the past 50 to 80 years.

In comparing this congress with the preceding one, held 5 years ago in Denmark, I see improvement in quality and in quantity. However, the "state of the art" is not wholly satisfactory. As the retiring president, Rudolf Spärck, pointed out in 1953, "general congresses have their place as well as specialized ones." But one might point out that most of the papers were either too general or too specialized to draw more than 20 to 40 in an audience at one time. Indeed, many talks were more sparsely attended. One can ask why. It is perhaps because zoology is so much a personal and individualistic pursuit of knowledge. A sense of wonderment at the prodigality of nature seems to have precluded intellectual content to some extent. Such a view still favors descriptive science over experimental. Most papers dealt overwhelmingly with the past, such as that on jaw articulation in Mesozoic mammals. Only approximately 15 percent dealt with what might be called zoology of the future.

There was an excellent rotational program of biological motion pictures, presented each day. Interesting documentary films were shown on the life of seals, the life of termites, the life of Linnaeus, whaling in the Faeroes, insect parasitology, African turtles, egg temperature experiments on nesting herring gulls, the social life of monkeys, the Galapagos Islands, the wild cattle of Cambodia, and other fascinating subjects.

A delegation headed by E. Witschi of the University of Iowa extended an invitation to hold the congress in 1963 in the United States. It was announced by Sir Gavin de Beer, for the Permanent Committee on International Congresses of Zoology, that this invitation had been accepted.

W. R. Duryee
George Washington University School of Medicine, Washington, D.C.

Microscopy and Microradiography

The second International Symposium on X-ray Microscopy and X-ray Microanalysis will be held at the Karolinska Institutet in Stockholm, Sweden, 15–17 June 1959. The symposium will be divided into three main sessions devoted to the use of absorption, emission, and diffraction of x-rays as microanalytical tools. These sessions will be subdivided into instrumentation and, according to the type of application, into biological and nonbiological applications. Thus contributions will be welcomed from a variety of research fields, ranging from pure instrumentation in x-ray microscopy and microanalysis to the application of x-ray microanalytical methods in biology, geology, medicine, metallurgy, and other fields. At the end of each main session there will be a panel discussion to summarize the recent advances and to assess future developments.

The allotment of time for each contributed paper will be 15 minutes, including discussion. Papers should be presented in English, French, or German. Titles must reach the symposium office not later than *1 December*. The deadline for submission of abstracts for publication in the program is *15 February 1959*. Correspondence should be addressed to: Second Symposium on X-ray Microscopy and X-ray Microanalysis, Dr. G. Höglund, Institutionen för Medicinsk Fysik, Karolinska Institutet, Stockholm 60, Sweden.

Forthcoming Events

November

27-29. Central Assoc. of Science and Mathematics Teachers, 58th annual, Indianapolis, Ind. (N. G. Sprague, Indianapolis Public Schools, 1644 Roosevelt Ave., Indianapolis 18.)

28–6. International Conf. of Social Work, 9th intern., Tokyo, Japan. (J. R. Hoffer, Intern. Conf. of Social Work, 345 East 46 St., New York 17, N.Y.)

30–5. American Soc. of Mechanical Engineers, 79th annual, New York, N.Y. (O. B. Schier, ASME, 29 W. 39 St., New York 18.)

December

1–3. American Soc. of Refrigerating Engineers, New Orleans, La. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

1–4. Entomological Soc. of America, Salt Lake City, Utah. (R. H. Nelson, 1530 P St., NW, Washington, D.C.)

1–5. American Rocket Soc., 13th annual, New York, N.Y. (A. F. Denham, 925 Book Bldg., Detroit 26, Mich.)

1–5. National Power Show, New York, N.Y. (O. B. Schier, II, ASME, 29 W. 39 St., New York 18.)

2. Scientific Study of Glass, 11th technical meeting of the European Union, Paris, France. (Société française de céramique, 44, rue Copernic, Paris 16e.)

2–4. Electric Steel Furnace Conf., 17th, Cleveland, Ohio. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

2–5. American Medical Assoc., clinical meeting, Minneapolis, Minn. (G. F. Lull, 535 N. Dearborn St., Chicago, Ill.)

3. Animal Care Panel, 9th annual, Chicago, Ill. (R. J. Flynn, Argonne Natl. Laboratory, Lemont, Ill.)

3–5. American Inst. of Electrical En-

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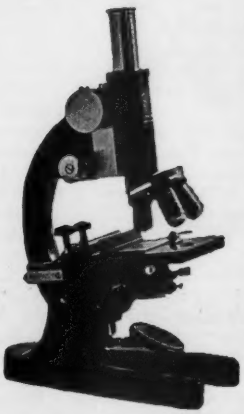

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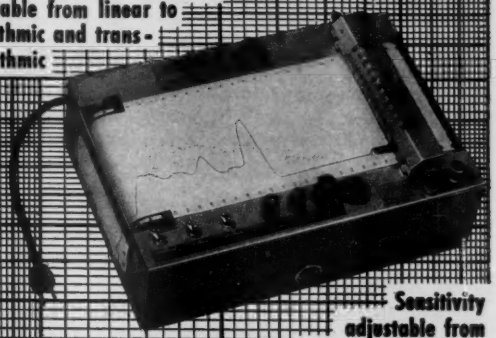

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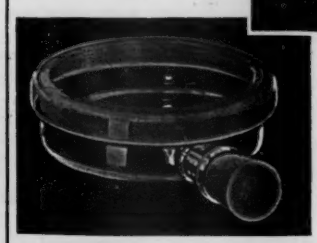

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3–5. Eastern Joint Computers Conf., Philadelphia, Pa. (G. W. Bailey, IRE, 1 E. 79 St., New York 21.)

3–5. Global Communications, 2nd natl. symp., St. Petersburg Beach, Fla. (M. R. Donaldson, 1501 72 St. N., St. Petersburg.)

4–5. Vehicular Communications, annual, Chicago, Ill. (G. W. Bailey, IRE, 1 E. 79 St., New York 21.)

5–7. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

6. American Rheumatism Assoc., Rochester, Minn. (E. F. Hartung, ARA, 580 Park Ave., New York, N.Y.)

6–11. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, Mayo Clinic, Rochester, Minn.)

7–10. American Inst. of Chemical Engineers, annual, Cincinnati, Ohio. (F. J. Van Antwerpen, 25 W. 45 St., New York, N.Y.)

8–10. American Nuclear Soc., winter, Detroit, Mich. (ANS, P.O. Box 963, Oak Ridge, Tenn.)

9–10. Conference on Learning Effectiveness, Univ. of Pennsylvania, Philadelphia, Pa. (Air Force Office of Scientific Research, Air Research and Development Command, U.S. Air Force, Washington 25.)

10–16. American Acad. of Optometry, annual, Boston, Mass. (C. C. Koch, 1502 Foshay Tower, Minneapolis, Minn.)

12–13. Association for Research in Nervous and Mental Disease, annual, New York, N.Y. (R. J. Masselink, 700 W. 168 St., New York 32.)

15–17. American Soc. of Agricultural Engineers, winter, Chicago, Ill. (J. L. Butt, American Soc. of Agricultural Engineers, St. Joseph, Mich.)

15–19. Radiation Biology, 2nd Australian conf., Melbourne, Australia. (J. H. Martin, Physics Dept., Cancer Inst. Board, 483 St. Lonsdale St., Melbourne, Victoria.)

17. Institute of Aeronautical Sciences, Washington, D.C. (R. R. Dexter, IAS, 2 E. 64 St., New York 21.)

18–20. American Physical Soc., Los Angeles, Calif. (K. K. Darrow, APS, Columbia Univ., New York 27.)

26–31. American Assoc. for the Advancement of Science, annual, Washington, D.C. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 47 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Committee on the Social Aspects of Science (C. D. Leake, Ohio State Univ. College of Medicine, Columbus, Ohio). 27 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (J. W. Buchta, Univ. of Minnesota, Minneapolis, Minn.). 28 Dec.

Academy Conf. (J. A. Yarbrough, Meredith College, Raleigh, N.C.). 27–28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 27 Dec.

American Assoc. of Clinical Chemists (Miss E. G. Frame, Clinical Center, Natl. Institutes of Health, Bethesda 14, Md.). 29–30 Dec.

American Assoc. of Scientific Workers (R. J. Rutman, 6331 Ross St., Philadelphia 44, Pa.).

American Astronautical Soc. (R. Fleisig, 58 Kilburn Rd., Garden City, N.Y.). 27–30 Dec.

American Geophysical Union (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5).

American Meteorological Soc. (K. Spengler, 3 Joy St., Boston, Mass.).

American Nature Soc. (S. Mulaik, Biology Dept., Univ. of Utah, Salt Lake City). 26–30 Dec.

American Physiological Soc. (F. A. Hitchcock, Ohio State Univ., Columbus).

American Political Science Assoc. (E. M. Kirkpatrick, APSA, 1726 Massachusetts Ave., NW, Washington, D.C.). 27 Dec.

American Psychiatric Assoc. (L. J. West, Univ. of Oklahoma School of Medicine, Oklahoma City 4). 27–28 Dec.

American Soc. of Criminology (D. E. J. MacNamara, Dean, New York Inst. of Criminology, Inc., 40 E. 40 St., New York 16). 27–28 Dec.

American Soc. of Naturalists (J. Schultz, Inst. for Cancer Research, Philadelphia, Pa.).

American Soc. of Photogrammetry (R. G. Ray, U.S. Geological Survey, Washington 25). 29 Dec.

American Soc. of Zoologists (G. Moment, Dept. of Biology, Goucher College, Towson, Baltimore 4, Md.). 27–29 Dec.

American Sociological Soc. (K. Davis, Inst. of International Studies, Univ. of California, Berkeley 4). 29 Dec.

Association of American Geographers, Middle Atlantic Div. (J. E. Guernsey, 9707 Parkwood Dr., Bethesda, Md.). 29 Dec.

Association for Computing Machinery (J. Douglas, Mathematics Dept., Rice Inst., Houston, Tex.).

Astronomical League (Miss G. C. Scholz, 410 Mason Hall Apts., Alexandria, Va.). 26 Dec.

Biometric Soc. (J. Cornfield, Johns Hopkins Univ., Baltimore, Md.). 30 Dec.

American Statistical Assoc. (E. Glazer, 305 George Mason Dr., Falls Church, Va.). 30 Dec.

Conference on Scientific Communication Problems (G. L. Seeilstad, Technical Reports Group, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.). 28–30 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 30 Dec.

Ecological Soc. of America (D. E. Davis, Johns Hopkins Univ., School of Hygiene, Baltimore, Md.).

History of Science Soc. (M. C. Leikind, 1334 Aspen St., NW, Washington 12). 29 Dec.

Instrument Soc. of America (O. L. Linebrink, Battelle Memorial Inst., Columbus, Ohio). 30 Dec.

International Geophysical Year (H. Odishaw, National Acad. of Sciences, Washington 25). 29–30 Dec.

Junior Scientists Assembly (K. C. Johnson, Supervising Director of Science, District of Columbia Public Schools, Woodrow Wilson High School, Washington 16). 27–28 Dec.

Metric Assoc. (J. T. Johnson, 694 W. 11 St., Claremont, Calif.).

National Acad. of Economics and Political Science (D. P. Ray, Hall of Government, George Washington Univ., Washington, D.C.). 27 Dec.

National Assoc. of Biology Teachers (P. Klinge, Jordan Bldg., Indiana Univ., Bloomington). 26–30 Dec.

National Assoc. for Research in Science Teaching (E. S. Obourn, U.S. Office of Education, Washington 25). 26–30 Dec.

National Assoc. of Science Writers (J. Billard, U.S. News and World Report, Washington, D.C.).

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 30 Dec.

National Science Teachers Assoc. (W. A. Kilgore, District of Columbia Teachers College, Washington 9). 26–30 Dec.

National Speleological Soc. (W. E. Davies, 125 Greenway Blvd., Falls Church, Va.). 28–29 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio).

Pi Gamma Mu (Mrs. Effie B. Urqhart, Winfield, Kan.).

Scientific Research Soc. of America (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.).

Sigma Delta Epsilon (Mrs. V. L. Blackford, 2630 Adams Mill Rd., NW, Washington 10). 26–30 Dec.

Society for General Systems Research (R. L. Meier, Mental Health Research Inst., Univ. of Michigan, Ann Arbor). 29 Dec.

Society for Industrial Microbiology, Washington section (W. N. Ezekiel, Bur. of Mines, Washington 25). 27–28 Dec.

Society of the Sigma Xi (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Society of Systematic Zoology (G. W. Wharton, Dept. of Zoology, Univ. of Maryland, College Park). 26–30 Dec.

United Chapters of Phi Beta Kappa (C. Billman, 1811 Q St., NW, Washington, D.C.). 27 Dec.

Washington Acad. of Sciences (G. W. Irving, ARS, U.S. Dept. of Agriculture, Washington 25).

27–29. American Economic Assoc., Chicago, Ill. (J. W. Bell, AEA, Northwestern Univ., Evanston, Ill.)

27–29. Econometric Soc., Chicago, Ill. (R. Ruggles, Box 1264 Yale Station, Yale Univ., New Haven, Conn.)

27–30. American Folklore Soc., New York, N.Y. (MacE. Leach, AFS, Univ. of Pennsylvania, Philadelphia, Pa.)

28–30. Archaeological Inst. of America, Cincinnati, Ohio. (L. A. Campbell, AIA, Dept. of Classics, Brooklyn College, Brooklyn, N.Y.)

29–30. National Council of Teachers of Mathematics, New York, N.Y. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

28–30. Western Soc. of Naturalists, Seattle, Wash. (J. P. Harville, San Jose State College, San Jose 14.)

(See issue of 17 October for comprehensive list)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 1098.

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■ ALIGNMENT TELESCOPE consists of a 17-in. telescope and an 8-in. reflector. The telescope remains fixed while the reflector moves along the line of inspection. Discrepancies are measured between the optical center of the reflector and the optical axis of the telescope within the limits ±0.04 in. Flatness, alignment, and concentricity are measured to 0.00005 in. Addition of a divergent lens to the telescope permits angular measurements. Precision of ±0.25 sec is obtainable. (F. T. Griswold Mfg. Co., Dept. 441)

■ EXPERIMENTAL EARPHONES effect noise reduction by furnishing an interfering wave. A miniature microphone in the earpiece creates a signal opposite in phase and equal in amplitude to the ambient noise. Low-pitched sounds are reduced to one-tenth their original volume. Higher pitched sounds are absorbed by a foam cushion. (Radio Corporation of America, Dept. 442)

■ VERTICAL ILLUMINATOR for stereoscopic microscope provides vertical shadowless illumination of deep, small-diameter orifices when the angle is too acute for standard oblique illumination methods. The illuminator consists of a lamp housing with bracket for attachment to the manufacturer's microscope stand, a vertical reflector, and a variable transformer. (American Optical Co., Dept. 444)

■ GAS CHROMATOGRAPH achieves detection by burning gases emerging from the column and monitoring the temperature of the flame. A thermocouple of very low thermal inertia is used to measure flame temperature. A mixture of hydrogen and nitrogen is used as the carrier gas. Exit gas is ignited initially by a spark. A regulated compressed-air supply is fed into the combustion chamber to support combustion. On full sensitivity, 10^{-7} g of hydrocarbon per milliliter of carrier gas is said to be detectable. The area of the chromatogram peak, corrected for heat of combustion, is proportional to the weight of the substance present. Sensitivity and stability are independent of temperature. Substances with boiling points up to 375°C can be analyzed. (Shandon Scientific Co., Ltd., Dept. 448)

■ CARBON-14 LABELED COMPOUNDS listed in 1958 catalog include 38 new compounds. Prices and ordering information are given. Among the new compounds are guanine-2-C^{14}, guanine-8-C^{14} and thymine-2-C^{14}. (Research Specialties Co., Dept. 454)

■ CENTRIFUGE features a control panel that may be lifted out of the basic instrument housing for remote operation. Interchangeable rotors provide versatility. Among these are an anodized aluminum rotor providing forces up to 34,800 *g* with capacity of 400 ml divided among eight compartments; an eight-tube continuous flow system; and an eight-cell particle-counting rotor (Ivan Sorvall, Inc., Dept. 453)

■ PERMANENT MAGNET has field strength 1,717.5 gauss ±0.1 percent and maximum field inhomogeneity at gap center of 40 mgauss over a 2-in. region. Gap is 2-in. thick by 10-in. in diameter. Series-connected sweep coils provide a maximum sweep amplitude of 40 gauss peak-to-peak with current sensitivity of 750 mgauss/ma. Weight is 375 lb. (Schlumberger Well Surveying Corp., Dept. 447)

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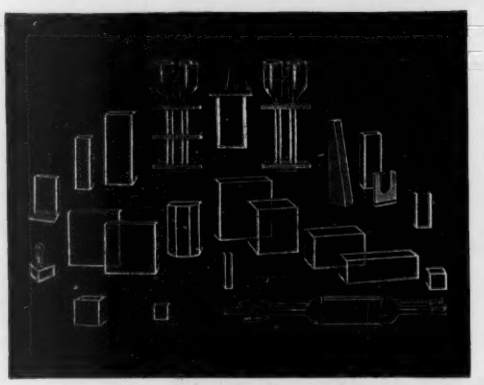

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Biologist: M.S. (chemistry minor); technical pharmaceutical experience. Desirous of position in medical writing or related field. Publications. Box 225, SCIENCE. 10/31; 11/7

Zoologist, with M.S., professional research experience in entomology and physiology, publications, and having completed formal work leading to Ph.D., desires teaching or combination teaching-research position at college or university. Box 227, SCIENCE. 10/31

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Biologist. Completed graduate work leading to Ph.D.; $5880–$7344; to study ecology and pollution of estuaries of Virginia. Virginia Fisheries Laboratory, Gloucester Point, Virginia. 9/19, 26; 10/3, 10, 17, 24, 31

Biologist, Histologist, Histochemist, Ph.D. or equivalent. Research institute, New York—to work in the field of experimental diabetes. Starting salary $7500. Box 228, SCIENCE. 10/31; 11/7, 14

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31 October 1958

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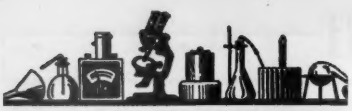

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31 October 1958

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METALLURGISTS • PHYSICAL CHEMISTS • SOLID STATE PHYSICISTS • CERAMISTS

ARE YOU OVERLOOKING SOME OF THE MOST CRITICAL CHALLENGES IN THE MATERIALS FIELD?

Listen in on this interview with Dr. A. E. Focke, Manager Materials Development at General Electric's Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio

Q. ***Dr. Focke, I have heard it said that the Aircraft Nuclear Propulsion Program adds a new dimension to materials technology. Do you agree?***

A. Strictly speaking, Mr. Walsh, reactor development for any application may be said to do this, since materials must be selected for their nuclear as well as their physical properties.

For some applications we look for high neutron absorption cross sections; for others, low capture cross sections.

For example, the material selected for the *moderator* must be capable of slowing down the neutrons produced by fission to thermal energy, about 1/40 ev from their original energy of several million ev with a minimum loss of neutrons by parasitic capture. *Control rods* on the other hand, must have high capture cross section for neutrons.

In practically all material applications for the nuclear power plant for aircraft which we are developing here, however, we have a high temperature problem of dimensions unique in materials technology.

Q. ***Why is that, Dr. Focke? Aren't these problems similar to those already solved for marine nuclear propulsion?***

A. In the ANP program weight and size are severely limiting factors. Here we are dealing with a small, high density reactor a small fraction of the size and weight of the submarine reactor. To jam high energy into small volume requires the development of high temperatures. Generally the higher the reactor exit-air temperature, the better the overall performance of the power plant.

The crux of the problem here is the fact that common materials desired for some parts of the reactor for nuclear considerations, cannot operate at the maximum temperature of the over-all system.

These charts, prepared for a recent paper will give you a better conception of the materials problem. Fig. 1 summarizes the general requirements. Figs. 2, 3 and 4 review a few of the basic physical properties of each of 11 metals selected for discussion.

Q. ***Can a materials man work effectively at ANP without previous training in nucleonics?***

A. Certainly. All the orthodox skills of the metallurgist, ceramist or chemical engineer are called into play here. The Aircraft Nuclear Propulsion Department will provide necessary training and information in nucleonics.

Q. ***What you've just told me, Dr. Focke, I certainly can discern the challenge to the materials man that you have here. I suppose you are working with alloys of some of the more exotic metals so much discussed in the latest technical literature?***

A. Security limitations forbid my naming specific materials on which we are concentrating our investigations at this time. We have, however, made considerable progress, though a great deal of work remains to be done before our first high performance nuclear power aircraft makes its maiden flight.

One of our principal problems is to be sure we have people with the required technical competence and specific abilities to function effectively.

Component	High Strength At High Temp.	Ability to Resist Oxidation	Neutron Absorption Cross Section	Density	Special Requirements
Fuel Elements	x	x	Low	--	Compatibility with fuel.
Moderator	x	x	Low	Low	Ability to slow neutrons to thermal effectively.
Control	x	x	High	--	
Shield					
a. Gamma	x	x	--	High(1)	(1) Ability to attenuate γ.
b. Neutron	x	x	High(2)	Low	(2) Ability to absorb without producing γ.

FIG. 1

Some characteristics of 11 metals in relation to possible application in Nuclear Power Plant for Aircraft—prepared by Dr. A. E. Focke, Manager, Materials Development.

Thermal Neutron Absorption Cross Section in Barns	
1. Hf	105.0
2. Re	84.0
3. Ta	21.3
4. W	19.2
5. U	7.68
6. Th	7.4
7. Ti	5.6
8. V	5.1
9. Mo	2.5
10. Cb	1.1
11. Zr	0.18

FIG. 2

Melting Point-°F	
1. W	6116
2. Re	5756
3. Ta	5426
4. Mo	4752
5. Cb	4474
6. Hf	4032
7. V	3452
8. Zr	3375
9. Th	3308
10. Ti	3020
11. U	2071

FIG. 3

Crystal Structure		Allotropic Transformation
1. Re	h.c.p.	NONE (known)
2. Hf	h.c.p.	b.c.c. 3020°F
3. Ti	h.c.p.	b.c.c. 1620°F
4. Zr	h.c.p.	b.c.c. 1584°F
5. Th	f.c.c.	b.c.c. 2426°F
6. W	b.c.c.	NONE
7. Ta	b.c.c.	NONE (known)
8. Mo	b.c.c.	NONE
9. Cb	b.c.c.	NONE
10. V	b.c.c.	NONE
11. U	ortho	tetra 1220°F; b.c.c. 1427°F

FIG. 4

Metallurgists, ceramists, physical chemists, solid state physicists with background in hi-temperature materials are invited to inquire about professional opportunities in these areas. Nuclear experience, while desirable, is not essential.

Write in confidence including salary requirements to: Mr. P. W. Christos, Professional & Technical Personnel—Division 63-WP

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GENERAL ELECTRIC

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Versatile New Scintillation Probe Detects Fast or Slow Neutrons, Gammas, and Betas

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Two neutron probes are offered for flux measurements in reactors or subcritical assemblies. The neutron sensitive volume is confined to the very ends of the 42" probes so that "point" measurements may be made easily. Probe housings are quickly removed to permit substitution of slow neutron or fast neutron sensitive phosphors. These long probes can also be supplied with sodium iodide crystals for gamma detection.

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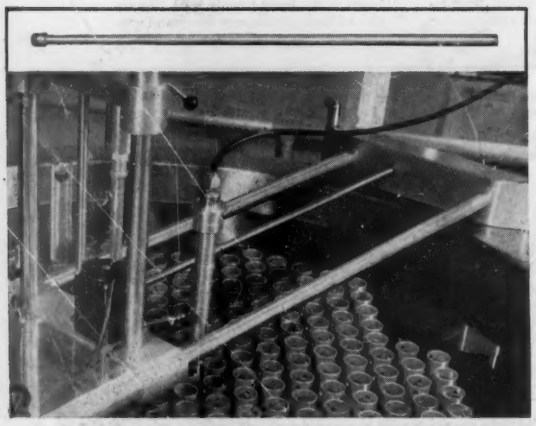
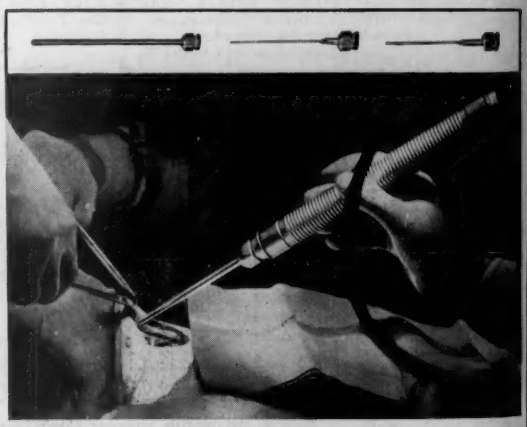
For more than 12 years we have been designing and manufacturing high quality, dependable instruments for detecting and measuring radioactivity. We will be glad to furnish you complete information on this new DS8 Scintillation Probe or on other Nuclear-Chicago instrumentation or our Research Quality Radiochemicals.



Shown here being used with Nuclear-Chicago Model 9000 Subcritical Training Reactor to measure slow neutron flux at various points in the lattice, neutron probes are 42" long and are available in two diameters, ¾" and 11/32".



Shown here in use during thyroid surgery, Model DS8 is offered with three beta-gamma sensitive needle probes 2 mm, 3 mm and 6 mm in diameter, 10 cm to 15 cm in length. All probes are easily interchanged by loosening a simple hand nut.

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